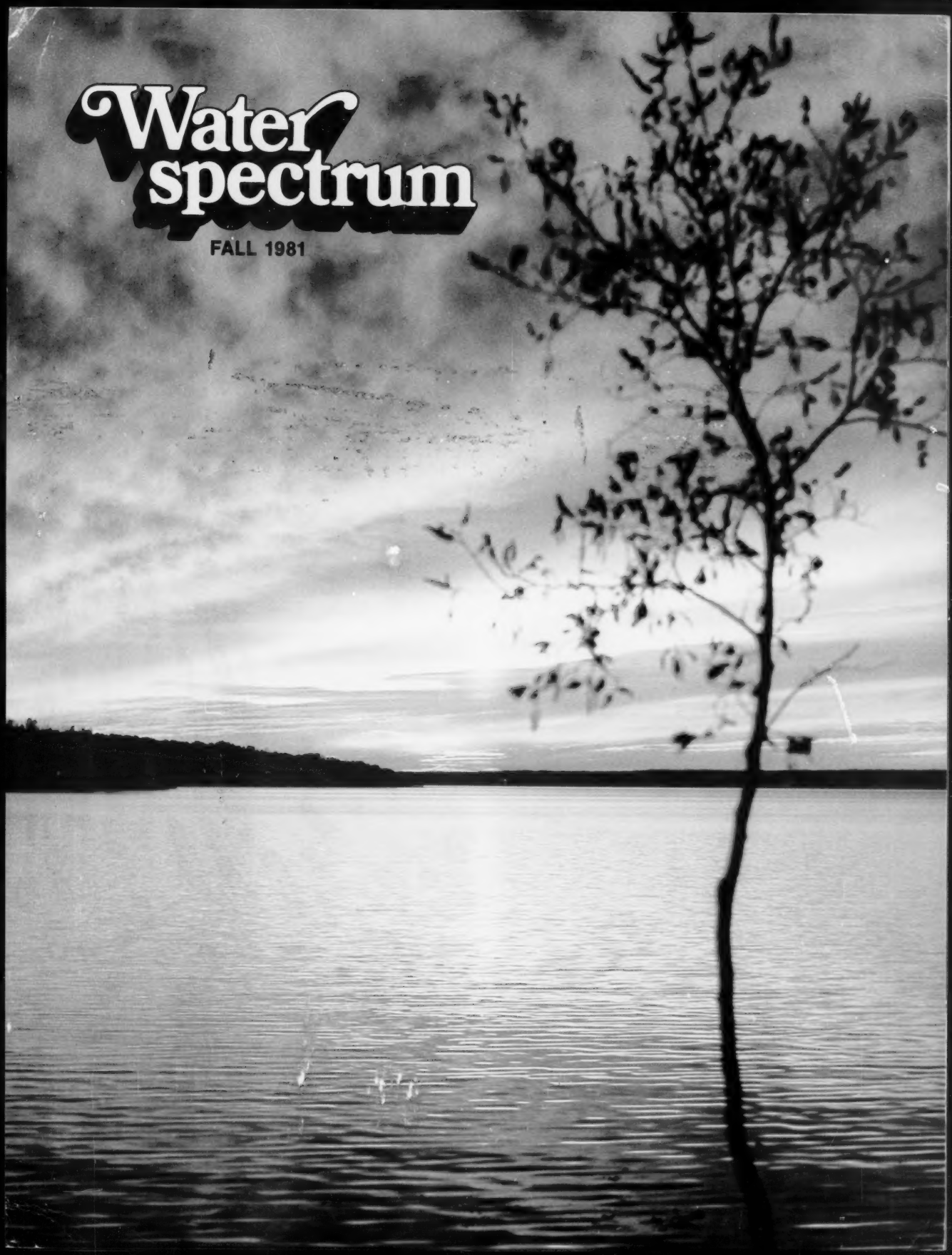
Water spectrum

FALL 1981



Water spectrum

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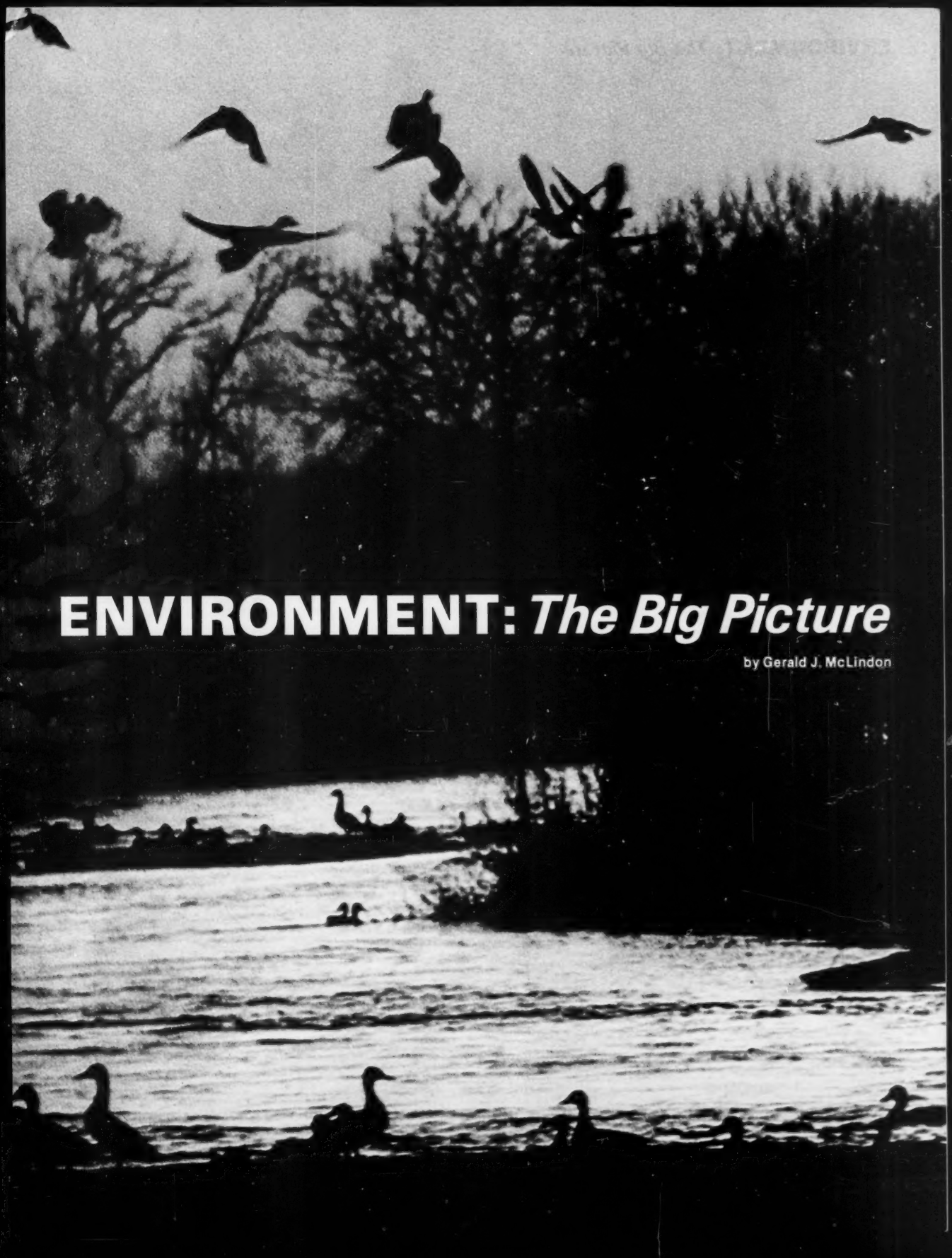
COVER: "The long sobbings of the violins of autumn
Wound my heart with monotonous languor."
—Paul Verlaine
(Photo by John E. Gannon.)



ENVIRONMENT: *The Big Picture*

by Gerald J. McLindon

It is over 10 years since the nation adopted the National Environmental Policy Act, which, with complementary legislation, forms what in time will be recognized as the Magna Charta Environmentalis. These acts have left no doubt about the nation's concern for natural systems and the need to emphasize a quality of life for people, now and in the future.

This achievement should foster a strong sense of satisfaction and an optimism for the future. There is no question about the progress made to date. But the present thrashing around under the flailing goads of inflation and recession fosters, instead, unease about environmental concerns in the years ahead.

Maybe the battles to achieve the present state of recognition of the environment have been too protracted to allow for any lowering of the guard. Perhaps the realization has come that inflation and recession are both the result of excesses and were predicted more than a decade ago. Yet we did not respond. Is it that we are unable to learn from history and remain committed to pursuing preambles to the crises which have come to characterize contemporary society? Perhaps educational systems have failed to instill the ability to discern the consequences of our actions. It is sobering to contemplate that the major decisions resulting in polluting of air, water and land have been made, not by high school dropouts, but by chemists, engineers, architects, business administrators, and others who have had the benefit of the very best we have to offer in education.

Whatever the reason, I sense we are entering an era when vigorous efforts will be forthcoming from those entrenched in the old ways to thwart environmental advancement and perhaps to weaken the standards already established. Rather than settling into a comfortable stance to implement environmental enhancements, we must become ever more vigilant in protecting what has been achieved and in pursuing the immense changes required to

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Air and water are not free commodities.
(Corps of Engineers photos.)

These acts have left no doubt about the need to emphasize a quality of life for people, now and in the future.

bring our environment and economy back into balance.

Looking back on the decades of the sixties and seventies we recall the vociferous environmental opposition of a large segment—but not all—of the business community. First there was the plea that environmental controls would destroy the economy. This was based on the erroneous idea that air and water were free commodities to be used at will for the disposal of wastes. We should have recognized that air and water serve ecological and human systems. Both air and water are subject to natural contaminants and, up to a point, can also cope with some man-made wastes and still recover. The danger came when the magnitude and compositions of wastes exceeded the recuperative capacities of nature.

The resistance from business and industry to the proposition that they must not disperse wastes in a wanton fashion demonstrated a lack of commitment on their part to the future and a negation of the spirit of free enterprise. The pollution of air, water and land destroyed or threatened to destroy ecological systems which are essential to the support of life on the planet. By their actions the despoilers forced individuals, other business and governmental entities to subsidize their operations. As a people, we paid for cleaning and treating water and air in reduced crop yields, reduced fish harvests, extra painting and maintenance of buildings, and that worst of all costs, impairment of health and in some instances death. I am not sure we can ever calculate the total costs of cleanup or of health maintenance required by pollution, but I would estimate they are several magnitudes greater than the price of eliminating the pollution at the source. We should recognize pollution control as a production cost and not treat it as a tax imposed by industry and communities on an unsuspecting people.

While some of the costs of pollution have been hidden, others are more blatant, exemplified by the use of "throwaway" containers in place of returnable bottles. State and local governments have been forced to spend billions of dollars to retrieve and dispose of this trash, instead of legislating the industries to recycle containers through their distribution processes. These subsidies are contrary to the concept of free enterprise and represent the thin edge of the wedge, inviting government to enter and regulate the industrial field.

An examination of the National Environmental Policy Act will reveal that none of the regulations would have been needed had we, as individuals and corporations, done our work in a practical and ethical manner. At most, an educational program should have sufficed to alert us to our responsibilities and, in keeping with our stated values, we should have responded. Before decrying any piece of legislation or

"Throwaway" containers exemplify the blatant costs of containers pollution.

regulation we should at least ask ourselves what we did, or did not do, to require government to step in as the national conscience.

One of the surprising reactions to environmental awareness was the tendency on the part of some businesses to portray environmentalists at best as uninformed do-gooders who had no concept of the complexities of business or the economy. Others were depicted as irresponsible characters espousing strange philosophies. Remember the names dubbed on those who would warn of the irrational use of resources or the consequences of environmental insults? We were hippies, doomsday prophets, little old ladies in tennis shoes.

The consequences of wasteful energy use are of recent vintage, but the crisis has been in the making for decades. In the 1930s I read an article written in 1927 by Dean Inge, a British religious leader. He drew attention to the wasteful manner in which oil was being used, and at that time the multifarious uses of oil were still developing. He projected the depletion of the resources, and, as I recall, the consequences of becoming dependent upon limited supplies held by a few nations.

The next surge of interest came in the late forties and into the fifties, this time prompted by the soulless character of urban sprawl. Concerned with the loss of farmlands, the flight from the central city, the despoilation of the countryside by automobile junkyards, the high percentage of land being devoted to automobile use and the problems of air and water pollution resulting from the illogical use of oil, strong pleas were made for better systems of mass transit to reduce dependence upon the auto and to cut back on air and water pollution. In the sixties and early seventies the cry continued, with the added warning that supplies were becoming limited and that as a nation we were allowing ourselves to become far too dependent upon oil as an energy source.

The pollution of air, water and land threatened to destroy ecological systems.

There were some responses. The problem of air and water pollution was dealt with effectively by regulation.

The transportation industry failed to react to the need for smaller, fuel efficient autos.

The compact car, introduced then, was a help, but it was not too long before Detroit and Madison avenue were telling us they had bigger and better compacts to the point where the "compacts" again became gas guzzlers. Perhaps the greatest tragedy of this period was the dissolution of the aerospace industry. Here was the greatest assemblage of scientists, engineers, managers, technicians, and workers ever assigned to a national peacetime project. They demonstrated the ability to undertake highly complex missions and to succeed in the most brilliant fashion. They should have been given a mission to develop new energy-efficient systems of mass and rapid transit. I recall efforts being made in the late sixties to have the National Aeronautics and Space Administration's (NASA) Mississippi Test

Facility converted into a great transit research laboratory. It never came to pass. Instead we gutted NASA and spent countless millions retraining great scientists in sociology, planning, and a host of other disciplines.

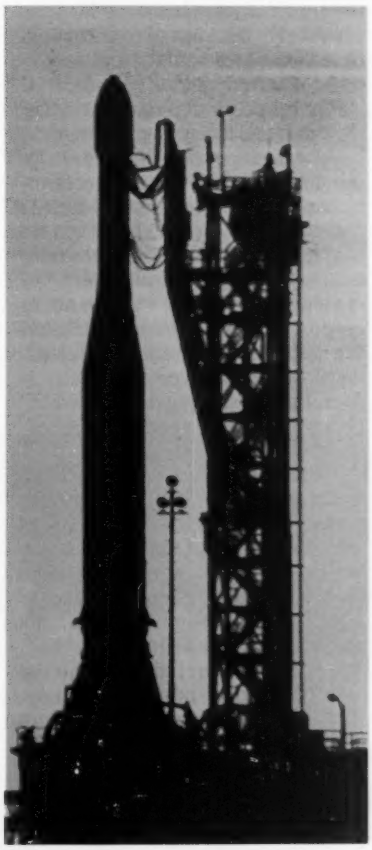
In 1973 and 1974 we were again warned in the most dramatic fashion of the dire consequences of continued heavy dependence upon oil. We reacted as though the whole episode were but a temporary inconvenience. The oil companies continued to emphasize marketing rather than stewardship. The automobile builders pursued the "big is beautiful" philosophy. The vicious spiral of inflation began with increased prices for crude oil and affected every segment of the economy. Failing to react to the need for mass transit and smaller, fuel-efficient autos, the transportation industry laid the groundwork for massive unemployment in the eighties. It is well to recall that environmental groups were urging changes to save natural resources—oil, ores, timber, rubber, and land; to reduce urban sprawl; to prevent air, water, and land pollution; and to bring the national economy into balance. We were told that this meant taking the nation back into the dark ages. Even in the late seventies as programs of energy conservation were advanced, the resistance to change persisted.

Let us be realistic. It is very popular to place the responsibility for present inflation and unemployment on the shoulders of government. The truth is that we as individuals, groups, and corporations have worked very hard to create inflation by our refusal to recognize that which is obvious and by continued pursuit of waste and greed, thinking only of ourselves and not of future generations. Because many industries, and in particular the automobile industry, operated on "demands" which were of their own making rather than responding to actual needs, the unemployment lines today are long and the automobile lots are full of high-priced anachronisms.

Most tragic is that in pursuit of these illogical and irrational policies American business has itself dealt a serious blow to the whole concept of free enterprise. Emphasis on short-term, high-payoff programs has led to increased governmental regulation, many government programs and an increased need for government to promulgate long-range policies for business.

The degree to which government control is exercised depends in large measure upon the manner in which responsibilities are met. An industrialist being interviewed on television recently offered as a reason for disposing of toxic wastes in a clay containment above a potable groundwater stratum the contention that he had to make a profit. All business must make a profit; that is the motivating force in free enterprise. But no business should make a profit at the risk of destroying potable water resources and possibly causing injury or death to users of that water. If the processes are such that the product is successful only if hidden subsidies have to be paid in the form of cost to governments to clean up, or the cost of damaged ecosystems or ill health or death for humans, then the business is not in free competition and does not belong in the marketplace. In effect what that industrialist said is that the company had not done sufficient research on the reason for toxic waste production or on the disposal of those wastes. They had not taxed their ingenuity or resourcefulness. They simply took their problem and transferred it to the community at large by burying it, literally and figuratively.

There are many places in which we can make a new start. Our institutions of higher learning, which in recent years have become the final sanctuary of the bureaucracy, must re-evaluate their mission to society. Nathan Pusey noted that it was proper for scholars to reside in an ivory tower, but it did not



Perhaps the greatest tragedy of this period was the dissolution of the aerospace industry.

hurt them to look out the window at the world around them.

How can business majors, chemists, and engineers hope to function in the contemporary world without some knowledge of human and natural systems? Although the design professions are supposed to be art and science, the science appears to have been forgotten in the pursuit of an illusive art. In the meantime our cities are chaotic, methods of construction obsolete and the needs of a vast segment of our population ignored.

For too long universities have judged their progress by looking at where they have been rather than where they should be going. While the professor belongs in the classroom, if indeed he represents the best thinking of our time then he must also be serving business, industry, and government. More money for education? Yes, but not to support tired and outmoded programs. We need scholarship and research of the most dynamic type and for all disciplines addressing the real philosophies, ethics and problems of the present and the future.

Now is the time for business, industry, academe, and government to join in an analysis of our needs and the projection of alternative futures. On the one hand we have a society committed to waste, creating "demands" for more resources to appease a gluttonous appetite for material things. On the other hand we have industry claiming that to reduce this production of waste with its associated pollutions is a return to the dark ages, a step that will ruin the economy and cause massive unemployment.

The greatest task facing us is a clear definition of what our needs are as differentiated from so-called demands. A recapitulation of our use of water will clearly show an incredible waste in industry, business, institutions, residences, and agriculture. We have grown up with the notion that there is all the water we could possibly use, and so we have developed our living and manufacturing habits on the concept of waste. The Office of Technology Assessment has predicted serious water shortages by the twenty-first century. If we start to redesign our use of water, the amount we will save will meet our needs well into the future. By doing that we will also help save our rivers and alluvial valleys from inundation for new water supply reservoirs. During the water conservation program at the time of the drought in California, a manager of a waterworks noted that he does not make profits on the water he does not sell. Nor does the nation benefit from the loss of prime farmlands and small farms or the inundation of habitat. There will be reason enough to claim some such lands for essential projects without destroying them to support waste. Similarly, the greatest immediate source of energy is in conservation. If we really wanted to, we could be independent of oil imports five years from now simply by reducing waste. As we switch to alternate energy sources we must also practice conservation; otherwise we will repeat the crisis of today. My great worry is that we will push the alcohol from grain program at the cost of food exports and high prices for food at home. I see nothing but grief in that approach to energy production.

We have grown up with the notion that there is all the water we could possibly use.

For years my pet peeve has been waste in packaging and planned obsolescence in household and other appliances. After your next weekly shopping, look at the amount of trash that accumulates as products go on the pantry shelves. Think of the forests

clear cut, the soil erosion, the water and energy used and the pollution and toxic wastes generated to produce this useless packaging . . . and remember that we pay for this waste. Keeping these producers in business is simply private enterprise welfare, the worst type of "make-work" programs.

If you can stand the smell, it would be most educational to spend a day at a sanitary landfill seeing the hundreds of tons of waste accumulate, much of it senseless production that has contributed nothing to the quality of life. There can be seen used metals being buried in a devastating array, so that recovery for future use becomes impossible. As I look on such scenes, I think of American dollars being spent overseas for ores, and of the financial, energy and pollution costs involved in production only to have the end product thrown away. If salvaged, these materials could be reused with benefit to our balance of payments and at little cost in energy or pollution. It is a sad fact that some of our scrap metals are sold overseas to be bought back by us as manufactured goods. A vigorous recycling industry must be developed in this country.

It is imperative that we as a nation assess our position, set our goals for the future, perhaps through a White House conference, and get on with the job. In doing this we must think holistically of people, the environment and the economy. This approach will strengthen each area and in total give us the quality of life we all seek. For environmental advisors in government agencies holistic thinking is essential. Whatever the department, they represent the people of this nation seeking the achievement of sound practice. To achieve the goal it is imperative to work in harmony.

If we cut out waste, will the economy suffer? No. Right now there are 23 million people in this nation who are illiterate. As such they cannot function effectively in the work force. Solving that problem is an industry in itself. Some 40 million people live in slums—right there is a building boom in the making which could last 20 years, and it is a program which can and must be fulfilled by private enterprise. There is need for new systems of rapid and mass transit in this country and overseas. Indeed, transit vehicles and systems to developing countries could become one of our greatest export industries. The list goes on and on. There is so much work to be done that, should we accept the challenge, the greatest problem may well be finding the workers to do it all. Rather than resorting to dark-age philosophies, we need research, greatly improved technology, and, above all, the brainpower that has languished while the nation, in its state of suspended animation, has pursued the old laissez faire policies. ■

There is need for new systems of mass and rapid transit in this country and overseas.

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Missouri flood, 1951. (Corps of Engineers photo.)

HOW LONG CAN YOU TREAD WATER?

FLOOD CONTROL IN THE MISSOURI VALLEY

by Ed Cass

The Missouri Valley is caught between a vision of flood and a spectacle of desert waste. Efforts to prevent both floods and droughts in the valley started in the nineteenth century. Improvement of the Missouri River for navigation began in 1838 but not until later in the century did thoughts of controlling the great stream for other purposes arise.

Efforts to prevent flood damage in the Mississippi system of which the Missouri is a part go back to 1717 when a levee was built to protect New Orleans. Levees required extensive periodic maintenance but were among the first means chosen to control floods on the Missouri. City governments, town fathers and individuals sought to protect small areas by erecting earth embankments. Few imagined it might be possible to control the flow at its sources. One exception was Charles Ellet, who, about mid-nineteenth century, suggested that reservoirs like those the English engineer Thomas Telford had designed in the early 1800s might work on Mississippi tributaries. Few listened to him.

As Missouri communities spread over the floodplains, huge inundations like that of 1844, or even small annual floods, became more and more dangerous and costly. The flood of 1881, the first large one in the post-settlements era, brought the inhabitants and their representative to the point of appreciating the hazards involved. Thus when in 1897 the Corps of Engineers' Hiram Chittenden suggested storing floodwaters for irrigation, there were listeners. Supporters of navigation soon understood that such storage could benefit their cause as well. Earlier doubts about the constitutionality of projects for general improvements had been swept away and Federal planning for water projects had become feasible.

General Nelson Miles, among others, supported Chittenden and called for Federal construction of reservoirs in arid regions. In 1902, when Chittenden argued against spending money to remove snags and improve channels on streams where not a half-dozen steamboats passed in a decade, he may have lost some supporters. Chittenden did not confine his suggestions to ones that would benefit irrigation alone. His ideas included controlling building on floodplains and preventing private construction that would hamper flood flows. The Kansas City flood of 1903, which brought the Missouri to 14 feet above the danger point, a bare two feet below the 1881 record, convinced him of the validity of his ideas.

While willing to send engineers to relieve the disasters brought about by floods, the government rejected suggestions that the Corps belonged in flood control or damage assessment and continued to dabble in stream clearance for navigation on little-used rivers. Even Chittenden modified his pro-reservoir stand in 1908 and cited an obsolete French study as justification for more levees to control lower

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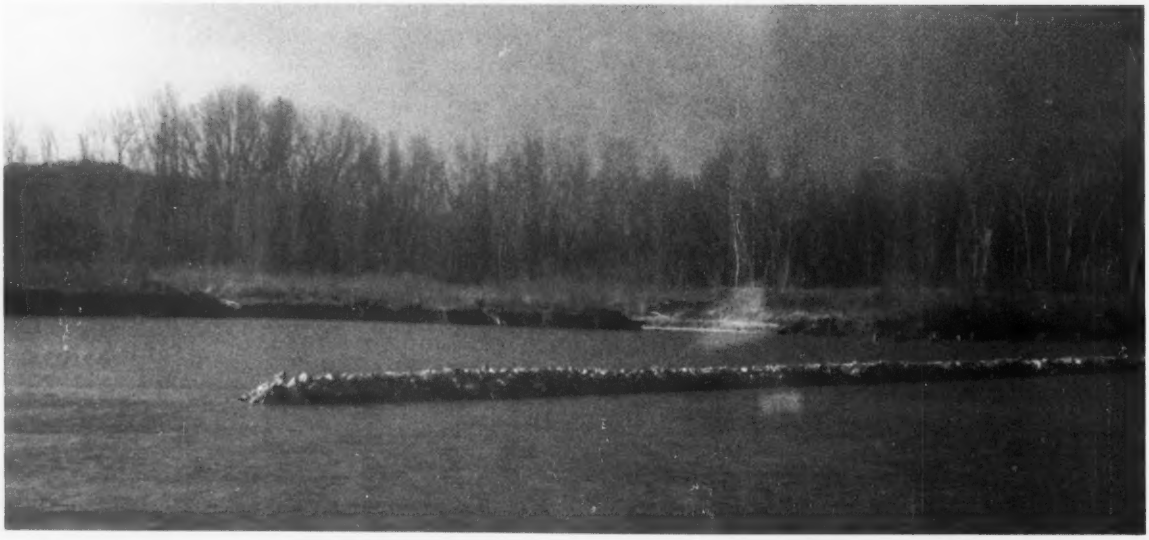
Mississippi River floods. He was not alone in his newfound opposition to reservoirs. The Corps' Major William W. Harts summarized the fears of reservoir opponents, saying they were unsafe, expensive, and slow to build and their complexity of operation and the likelihood they would quickly fill with sediment made them an unwise choice. Other means of flood control such as cutoffs at bends, levees and channel improvement, and upstream measures like deep plowing, contouring and reforestation received attention, but upstream controls were considered finally to be of little use on a large scale. By 1913, the use of cutoffs at bends had been thoroughly explored as a substitute for channel improvement, and most engineers had concluded that these were inadvisable. Extending bank protection work up and down the river from established levees and other structures continued to find support and meant that such projects would receive full consideration. Compromises whereby the funds for bank work would be raised by both Federal and local government organizations were worked out.

Between 1910 and 1920 Senator Francis Newlands and engineers like H. A. Patterson, writing in *Engineering Record,* began to prod the Congress and the engineering profession in the direction of multiple-purpose planning. Some Americans were carried away by the vast planning involved in the Panama Canal project and suggested constructing a canal from the Missouri River in the Dakotas south along the upper parts of the watershed east of the Rockies to the parched areas of Oklahoma and Texas. The canal would store floodwaters and carry barges: the argument was that it would bring about a whole new era of irrigated farming in the lands west of the Missouri-Mississippi river system. Similar proposals have appeared frequently in valley newspapers.

It is fair to ask what held up implementation of the variety of plans that were being suggested. The delay came primarily from the state of engineering knowledge, which had not yet advanced to the point where dams and their reservoirs could be safely and effectively constructed. Even simple earth levees often failed, and systematic collection of hydrologic data about what to expect for future floods was not yet complete. With increased knowledge about conditions over time and the construction of innovative structures like Wisconsin's Prairie du Sac dam, which was built on piles driven into sand, the state of the art was coming closer to making possible what man could imagine. The need for basin-wide planning and comprehensive development in the face of

Hillsdale Lake tributary dam construction.

Dikes hold the river in place. (Photos by the author unless otherwise noted.)



growing human and livestock populations and agricultural development and the increase in value of water meant that engineers would soon be called upon to demonstrate their proficiency. Congress authorized Federal flood control measures on the Mississippi and Sacramento rivers by 1917, and nearly simultaneously all pretense of bank control as only a navigation measure disappeared.

A 1920 report made at the behest of South Dakota suggested that not only dams but large hydroelectric power works be a part of future plans. The 1920s brought about a melding of flood control, power, irrigation and navigation into multiple-purpose projects, but the Missouri River was not the first to receive attention. The Ohio, upper Mississippi and Tennessee valleys, among others, posed less complex problems and had greater populations, and the new ideas were tried there first. Dams with locks for slack water navigation were constructed; the multiple dams helped flood control efforts. The floods of the 1920s demonstrated that there were inadequacies in Corps' plans and resulted in the creation of the Jadwin plan for the Mississippi and its tributaries. This plan gave impetus to plans for large dams as public works projects in the 1930s, an impetus which led to the construction of Fort Peck dam.

Levees alone could not protect the ever-growing cities of the plains. Fear that adding height to some of the levees would cause them to settle on their foundations was among the reasons for new ideas being sought. Congress called for studies of the nation's rivers in 1923, and the "308 Report" for the Missouri Valley appeared in the early 1930s. Plans of the 1920s which had culminated in the 1928 Flood Control Act freed the Corps from restrictions on its flood prevention role and freed the planners to consider whole watersheds. The 1200 pages of the 308 Report provided a basic plan for the valley, a plan founded on over a half-century of experience plus contemporary studies which sent Corps surveyors by car and foot as far as the Yellowstone and Milk rivers. Even river diversion projects like that proposed for North Dakota had their roots in 1920s planning.

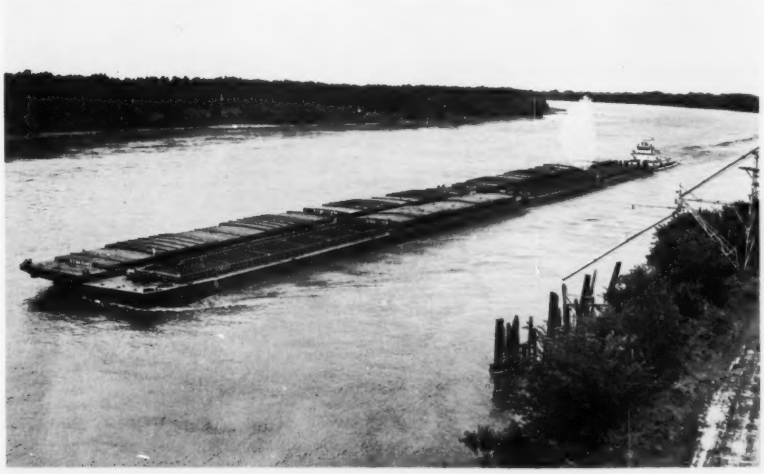
The questions that then had to be resolved included whether many low dams or a few high dams should be built, whether they should be constructed with or without locks and with or without sluices for sediment flushing, how much hydroelectric power to produce, and who was to receive the benefit of the stored floodwaters. An early plan calling for low dams with locks and backed by the Pierre Commercial Club and local Corps officers was disapproved by higher authority. The decision was made to press for navigation to Sioux City and to control the river above that point. Control would be obtained by placing a dam in Montana. Initially the belief was that dams below there between Fort Benton and Yankton would interfere with upstream releases and would silt up too rapidly. Objections to these would be dropped in the future as the need for utilizing water in a wider variety of modes became more evident. It was obvious, though, that the need to have empty reservoirs for flood control would conflict with irrigation, navigation and hydropower needs and that compromises would have to be worked out.

Nature did not wait for man, however, and floods and drought years continued to alternate. In some years floods hit one part of the basin while droughts prevailed elsewhere. The conditions of the thirties encouraged imaginative planning. Senator George Norris of Nebraska endorsed the Fort Peck reservoir and called for planning for the whole river.

Missouri tributaries continued to overflow: the Republican ran over its banks in June 1935. By 1935 flood stage at Kansas City had been exceeded at least 17 times in the century. Dams on the Kansas or Kaw, the Republican and Gasconade rivers and others were proposed as well as dams for the main river. A series of dams on the tributaries to the lower river would, it was argued, mean a lowering of the Mississippi by 26 inches in a 1927-type flood while simultaneously protecting residents on the lower Missouri and its tributaries. A 1935 Missouri River bill aimed at providing flood control through reforestation and dams for power and navigation. The need was evident; that same year a flash flood killed 105 people on Medicine Creek in Nebraska. From 1936 through 1938 a series of acts paved the way for future comprehensive plans, and the roots of the Pick-Sloan plan are in the laws and studies of the 1930s. Many future reservoir locations were selected by the late thirties; the Kanopolis, Milford and Tuttle Creek dams received their designation as high priority projects in these years.

Opposition arose to all these proposals—one state official in Missouri saying, for example, that dams in the Ozarks would destroy what little value was left, that of recreation, and create stagnant pools without really helping Mississippi floods. More voices would have been raised at the time, perhaps, had not dam and levee projects meant jobs for those desperately in need.

By 1940 it was felt that seasonal inundations could be controlled by dams and that levees and channel control works could control residual excess water as well as maintain the river in a navigable condition. There were fears, however, that some Corps activities were the cause of some local floods. In a 1939 Senate hearing, a farmer from



Towboat on the Missouri.

Nebraska City responded to a question from Senator Norris to the effect that he and his neighbors felt that the pile dikes holding the channel in position were obstructing the river and even moderate flows now backed up over the land. The general conclusion of the hearing, like others, was that Fort Peck dam alone would not suffice to control the river and that additional measures to stop flood were needed.

The drought-flood cycle continued—the years 1930, 1931, 1934, and 1936 brought drought to the northern Great Plains, and 1935 saw the Republican and Kansas rivers registering excessive May-June rises. The effects of this cyclic pattern upon farming brought the Department of Agriculture into the planning by 1938. The precedent-making Tennessee Valley Authority (TVA) Act of 1933 had paved the way for national action under New Deal auspices. The Federal agencies involved in Missouri Valley flood planning by 1940 thus included the Federal Power Commission, the Bureau of Reclamation, and the Department of Agriculture as well as the Corps. Desires for a TVA-like single organization gained impetus, but no "MVA" arose in the Missouri Valley. Its spectre, however, drove the agencies into a modus vivendi by the mid 1940s.

December 1941 threw a great many plans into temporary abeyance. When the Japanese struck Pearl Harbor, attention went to gearing up for war. The weather seemed unwilling to cooperate with the war effort, however, and warned the river engineers with a new series of floods. By 1941 plans for the dam at Kanopolis had passed the appropriation stage; plans for other dams came up against the question of where funds should go in wartime and were put aside temporarily. Kansas City planners expressed a need for new levees and said that a cutoff below the city at Liberty Bend was needed to drain water away from the heavily settled region. Proponents of comprehensive flood planning pointed out that the presence of industrialized areas and military bases on floodplains, like portions of Fort Riley, Kansas, meant that floods could inhibit the war effort if left uncontrolled.

In 1942 and 1943 nature responded with its own arguments. Heavy snows in the Dakotas in 1943 melted and sent the river over the Omaha airport. Colonel Lewis Pick asked for volunteers to man the levees; on April 15th the river crested at 22 feet, 12 feet above normal. Those few who could remember the flood of 1881 felt that bank work had helped to prevent a great deal more damage. When the flood subsided the Corps was asked to provide a solution, one that would satisfy the wide variety of needs in the valley. Since some of these needs were in areas for which other Federal agencies were responsible, the Corps' report, the Pick plan, was submitted to the Bureau of Reclamation, Federal Power Commission, and Department of Agriculture for comment. The plan called for implementing many of the recommendations of the 308 Report and subsequent studies. In addition to the nine dams which had been recently authorized by Congress for the Gasconade, Osage, Ellsworth, Republican and Big Blue rivers in the lower valley and in Colorado, the plan proposed five new dams

Missouri River main stem dam.
(Corps of Engineers photo.)

Kanopolis lake and dam. (Corps of Engineers photo.)

farther upstream in Nebraska and Colorado. Below Fort Peck on the Missouri main stem Pick would build five new large dams to hold back the river. At two points on the Big Horn and Yellowstone rivers over 2000 miles from the river's mouth other reservoirs would be built. The plan also called for a Garrison Diversion project in North Dakota and for continuous levees from Sioux City to the mouth of the Missouri. No proponent of this plan could be accused of thinking small. The Bureau soon responded with a comprehensive irrigation plan whose table of contents alone was almost half as long as Pick's original plan. The Sloan plan, as it was called, was designed by the Bureau's engineer in charge and amplified rather than replaced Pick's. Although there were areas of disagreement, it worked out that the two could be and were combined. The early negotiations left the Bureau's giant Oahe project intact and dropped the Corps' Oak Creek project, the site for which is inundated beneath Oahe's waters. The Bureau's Big Bend dam proposal was also worked into the overall plan and eventually built by the Corps. The smaller Bureau of Reclamation reservoirs that were approved remained that agency's responsibility, and many of the smaller Corps' proposed dams were turned over to the Bureau for construction.

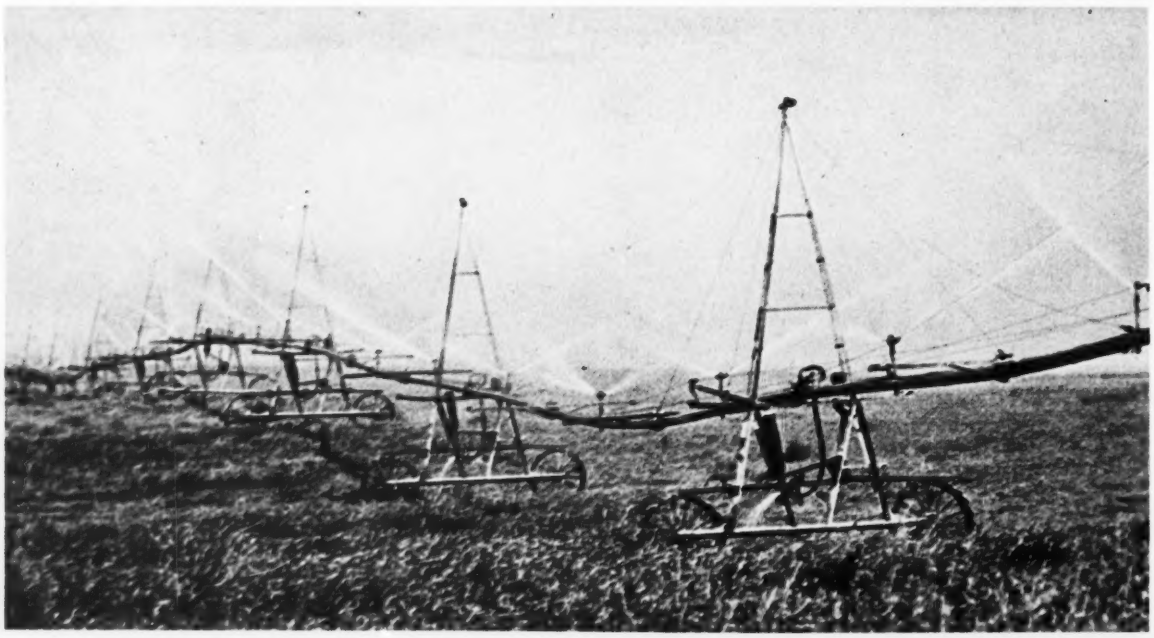
The creation and working out of these plans show a challenge and response pattern. Floods did not create immense problems for the aboriginal inhabitants; their flexible lifeways and the retention of water runoff by undisturbed grass and sod before technological man arrived precluded serious problems. The first settlers could avoid low-lying areas and often did so, perhaps more for the disease threat than that of floods. When trading posts became towns, then cities—cities served by rail as well as water—the problems began. Rails and roads followed the easiest routes along waterways. Steam vessels preferred water with a known depth and current. Shops and industries could not be moved from the paths of floods, yet these were most conveniently located on flat land near transportation routes. All this brought the residents into conflict with nature, a nature that was perceived as an opponent. The sod was turned, the rivers confined, the cities enlarged. Population growth peaked early in many parts of the valley but the monetary value of the lands and buildings continued to grow even in those areas.

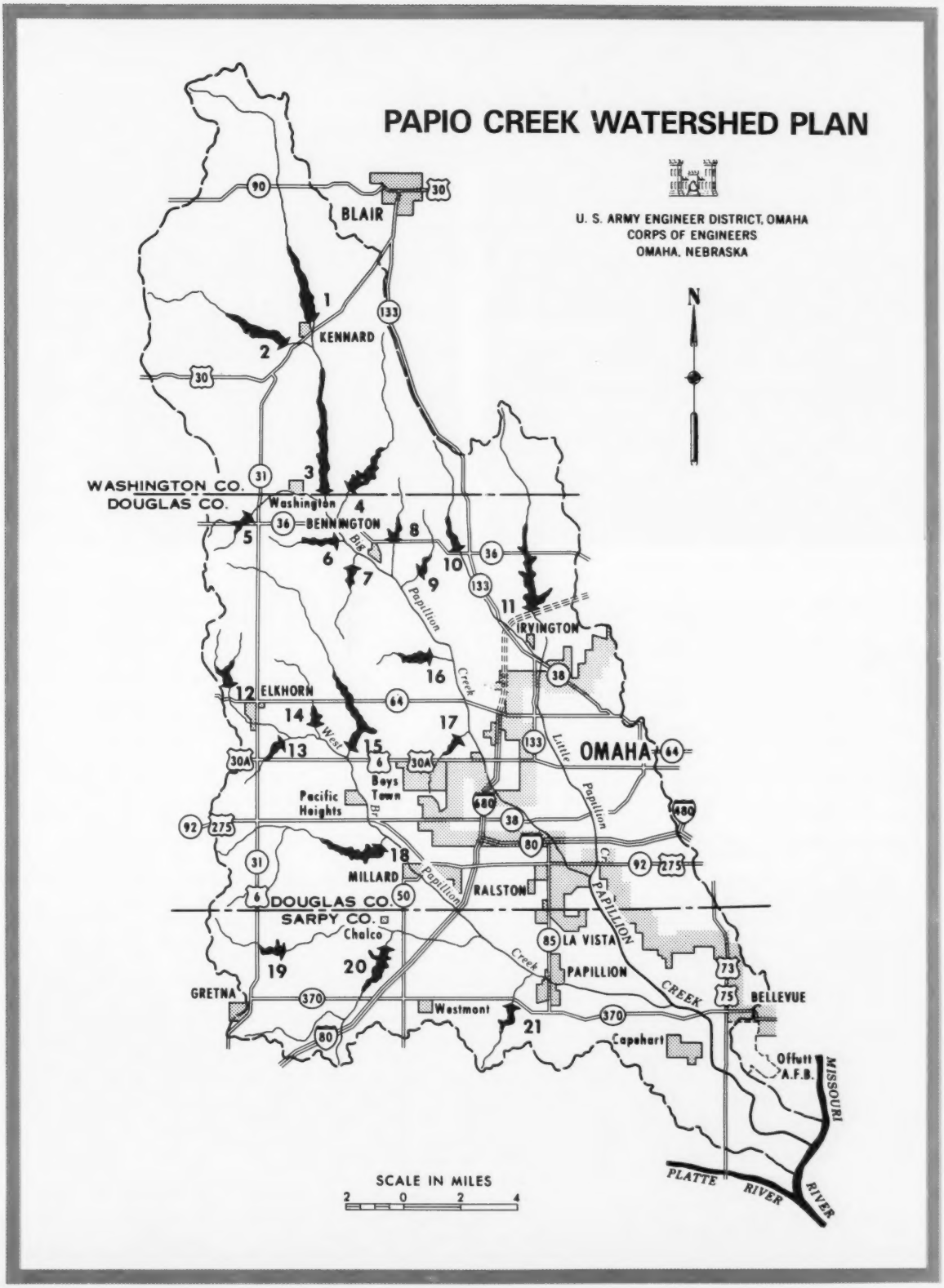
Ellet, Chittenden, Jadwin, Pick and Sloan built upon efforts of others and created a system of river control which has driven the nemesis of flood back into the small streams and tributaries. The threat of drought has receded somewhat as well, although not as much perhaps as it would have had all of the Bureau of Reclamation's plans been implemented. The creation of a Missouri Basin Inter-Agency Committee (MBIAC) brought Federal agencies and states together for long-range planning and alleviated some of the fears of a Federal takeover. Multiple use planning prevented unilateral approaches to regional problems as well. The plans of President Franklin D. Roosevelt, Senator Murray and others to create an MVA failed and left the states and agencies to work out the region's destiny.

With the end of World War II, the Pick-Sloan plan was implemented; between then and 1963 the main stem dams and many of the tributary dams were built and their reservoirs filled. Floods did not wholly disappear, nor did suffering end. Some areas felt the impact of the dams in dislocation of lives: 4000 people were displaced by one project, Tuttle Creek, alone. Others uprooted Indian peoples from land given them by treaty. The floods of the early 1950s meant that the projects would continue. In 1951 the Kansas River alone killed 44 people, caused $2.5 million in damages, and flowed at a rate double that of 1903.

Today one can stand at the mouth of the Missouri above St. Louis and

Irrigation farming.




PAPIO CREEK WATERSHED PLAN
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA
N
BLAIR
KENNARD
WASHINGTON CO.
DOUGLAS CO.
Washington
BENNINGTON
Big
Papillion
Creek
IRVINGTON
ELKHORN
West
OMAHA
Little
Boys
Town
Pacific
Heights
MILLARD
DOUGLAS CO.
SARPY CO.
RALSTON
Chalco
LA VISTA
PAPILLION
CREEK
GRETNA
Westmont
Capehart
BELLEVUE
Offutt
A.F.B.
MISSOURI
RIVER
PLATTE
RIVER
SCALE IN MILES
2 0 2 4

Jams and floods can result from drifting ice.

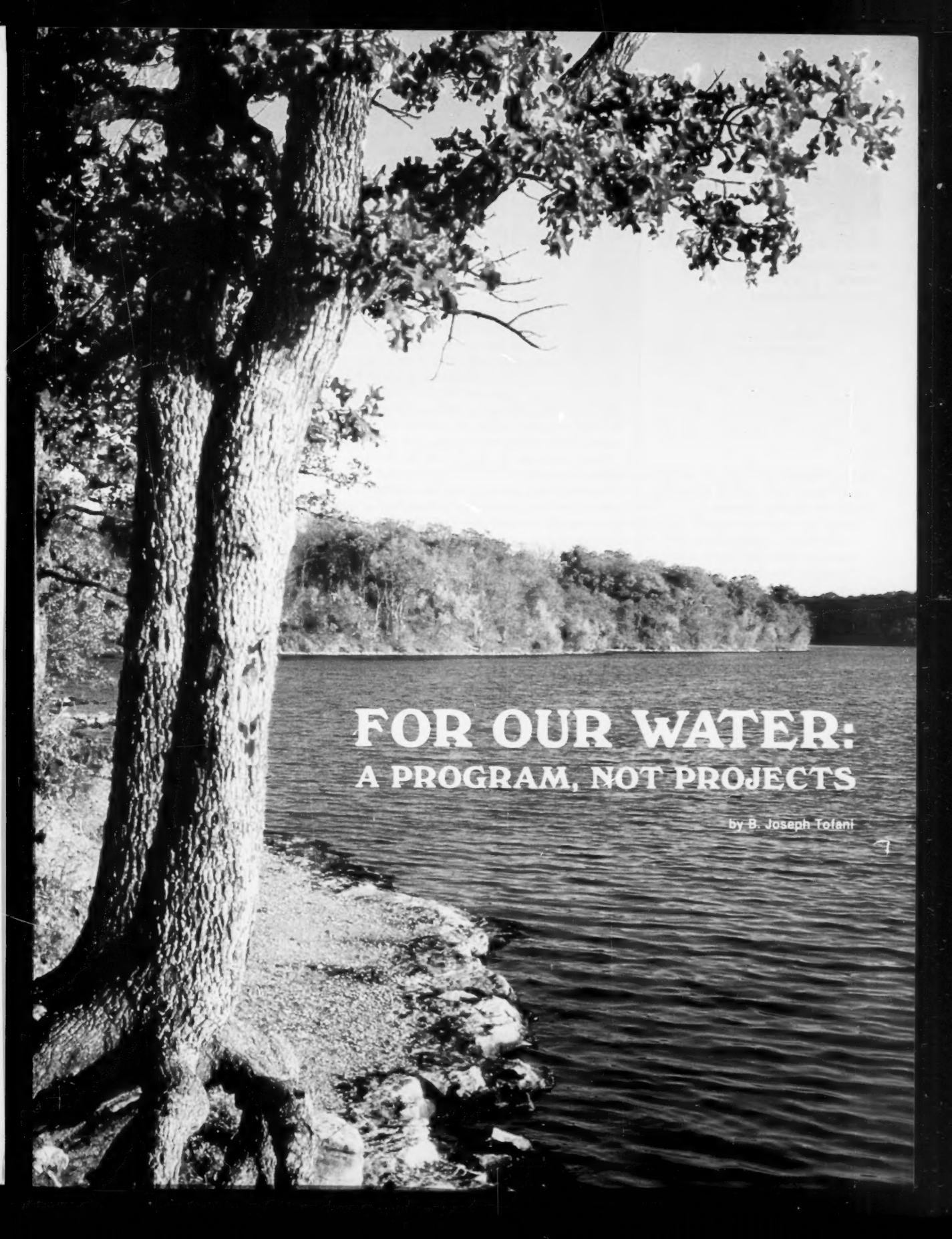
Iowa Creek.

watch water that may have run over a dozen spillways or spun the turbines at a half-dozen dams. Some of it may have been turned into fields and run back on its own to the river system. Much of the precipitation which came between January and June would have caused floods before reaching the mouth if it was not held back and made to serve human needs for agriculture, homes, and industries in one way or another before heading to the sea.

Since the early 1960s new uses have been suggested for the floodwaters. New projects, Truman dam and the Papio watershed protection scheme to name only two, have been initiated. Small Department of Agriculture dams supplement Bureau of Reclamation and Corps projects; soil conservation measures help retain the water where it falls, and the growing popularity of water conservation measures means that less will be wasted—saving the water itself is as important now as preventing damage. The attitude that each state is entitled to the water which flows into it as well as that which falls upon the soil causes problems and makes interstate water use pacts difficult to create. The Missouri River Division of the Corps, with its Omaha headquarters, finds itself a center of conflict over water use. Accidental deaths in reservoirs occur but are unlikely to equal the 800 deaths from floods between 1900 and 1950. Flood damages in the millions have been replaced by a salable product—stored water released to generating turbines or to cities and farms. Ideas like floodplain zoning to limit damage in those areas still subject to inundation need to be given a chance to work, and tax or other incentives for building outside of floodplains need to be provided. The 1960 Flood Control Act authorized the Corps to provide flood hazard information on request. Nationwide plans extend to the 1969 Flood Insurance Act and Presidential acceleration or deceleration of water projects. The Missouri Valley may prove so diversified in its needs and interests that in the future MVA type organizations will not arise, the looser MBIAC and various state organizations better meeting the realities of the vast area. Concerns with the environment have meant that some projects have been slowed or stopped. Of the 103 reservoirs in the Pick-Sloan plan, only 81 were completed or under construction in 1976. The standard project flood, or flood to be reasonably expected, may be exceeded and some flooding still occur. The economics of dam building necessitate taking some risk. The Australian term "flood damage mitigation" best fits the unified approach to flood prevention.

No single means of prevention can serve the region. Reservoirs can be full at the wrong time, levees can fail, debris or ice can jam under bridges or at narrow points, and evacuation must be possible when danger threatens. By 1973 $2.6 billion in damages may have been prevented by Corps projects. Many deaths have been averted and acres of farmland saved from eroding into the river. But 50 and 100-year forecasts are based on reliable data for just the past 100 years, and mistakes may have been made. Only wariness and continued thought can guarantee safety: we survived the record flow of 1978 but we cannot foresee when a new record will be set. Historically a static situation persists only for a certain length of time, and new solutions to flood control as well as other water use problems will need to be found at some time in the future. But it will remain true that water is to the land what blood is to the body into future centuries. ■

The gist of the material in this article was delivered earlier this year to the Missouri Valley History Conference and to the Missouri State Historical Society Conference.



FOR OUR WATER:
A PROGRAM, NOT PROJECTS

by B. Joseph Tofani

Water demand and water use will continue . . . and will increase.
(Corps of Engineers photos.)

For several years, the development of our water resources has gone steadily downhill. We are in a period of change, but this nation exists in periods of change; that will continue no matter what. We will always have shifting priorities, which we cannot forecast with a great deal of accuracy, but we can predict that water demand and water use will continue—and will increase. Increased use will breed conflicts, which we must resolve in order that we may have a proper balance in meeting not only our water requirements but other requirements as well.

We now appear to be in a holding pattern, born of the need to fight inflation, balance the budget and increase defense readiness. But perhaps we can turn this period to advantage by taking time to reflect, study and develop a water program.

During the early years of the nation, water resources development evolved piecemeal—and it has continued in that fashion. With every water crisis a slight interest develops and then quickly fades away.

Today's energy crisis gives evidence that a new demand has been placed on our water. While some preach that the path to energy security leads to alternate energy development, this is only part of the solution. Energy security can become a reality only if there is a parallel and aggressive effort to develop essential water resources that will be required to achieve this goal. Water and oil don't mix, but water and energy are inseparable. Almost every source of energy proposed requires tremendous quantities of water—water that is largely unavailable at the present time for such use.

Nor will water for energy be the last requirement we will place upon our water resources. We must not consider only future needs but we must continue to provide and improve for existing water needs. We cannot rely solely upon conservation as some define the term, as less demand and less use; we must practice true conservation, which is wise use.

In recent years we played a number's game. We have never established a program, a goal, or an objective in the development of our water resources,

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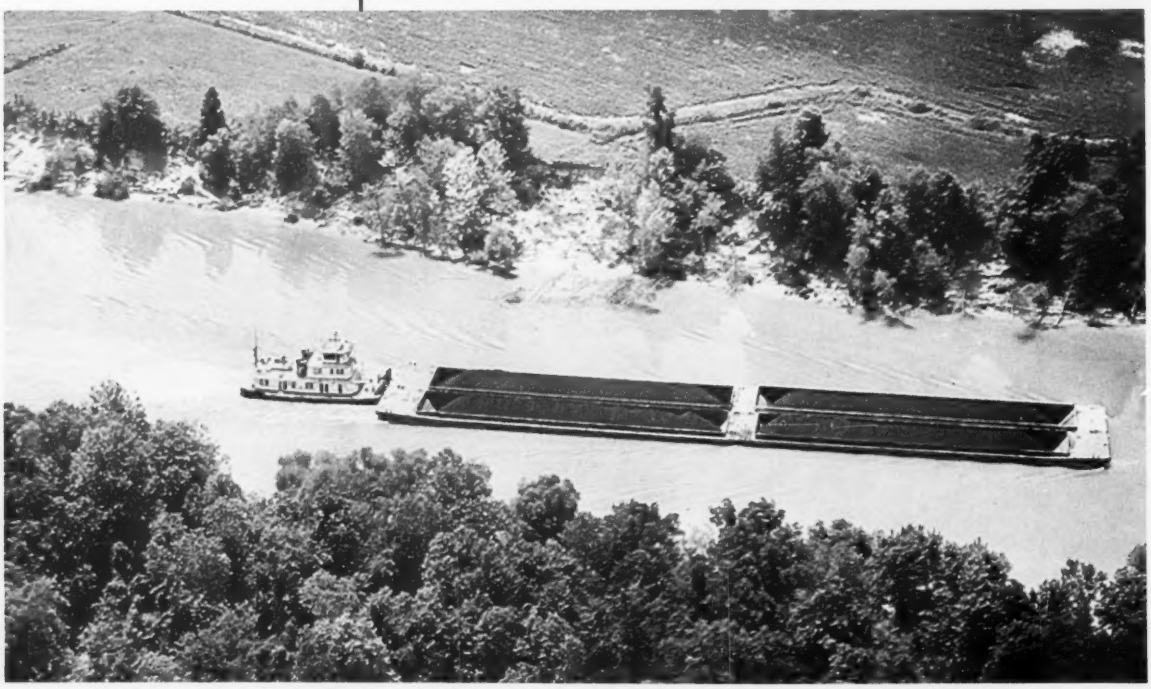
Mr. Tofani is president of the Water Resources Congress, Washington, D.C. 20024. This article is adapted from Mr. Tofani's statement before the U.S. Army Corps of Engineers' District Engineers' Planning Conference held in Leesburg, Virginia, in April 1981.

Today's energy crisis gives evidence that a new demand has been placed on our water.



Almost every source of energy proposed requires tremendous quantities of water.

but rather we have justified each individual project by so-called benefit to cost analysis. Today we have the National Environmental Policy Act, clean water, wild rivers, scenic river, trails, fish and wildlife, endangered species and many other acts all accompanied by new ground rules. Nature does not run out of water—people do. Nature does not plan for wise use of water—people do.

We are blessed with sufficient water but we face severe problems of availability and distribution at certain times in certain areas. This year witnessed the return of parched fields and low water supplies. And this problem is not peculiar to the west; it is also true in the water-rich east. New Jersey and New York, Pennsylvania plus the northern plains are finding their water supplies running low. Add to this the deteriorating water supply systems of many of our older cities, which will require multimillion dollar and in some cases billion dollar programs to rehabilitate, and the dimension of our water problem emerges.

Today, our nation and our people are paying a tremendous price for imported energy. While the price is having an effect on our people and our economy, the country is surviving. But let us imagine a similar problem in water. I do not believe we could buy our way out of a water crisis. It takes many years to study, plan and construct a project. It's time we change our thinking from projects to programs, if we are to meet our water needs.

Poor planning and I might say bad legislation have contributed to our present problem. Clean water is part of a total water program. Observe two examples from the wastewater treatment program and their results in context.

The General Accounting Office in November last year reported: "Over $25 billion in Federal funds and several billion more in state and local moneys have been spent to construct new wastewater treatment plants or to significantly modify existing plants. The Environmental Protection Agency estimates that through the year 2000 an additional $35.6 billion in Federal funds alone will be needed to construct additional treatment plants."

GAO found that many of the plants, in operation for several years, have seldom or never met the performance standards they were designed to achieve. "Failure of treatment plants to meet performance expectations may not only have an adverse impact on the Nation's ability to meet its clean water goals, but may also represent the potential waste of tens of millions of dollars in Federal, State and local moneys," according to the GAO.

I believe some of these funds could have and should have been put to better use if we had developed a water program.

One more example. An article from the October 1979 issue of *Civil Engineering* is titled "Do Federal Grants Force Cities to Build the Wrong Things?"

Nature does not run out of water —people do.

The City of New York is building a massive municipal sewage plant on the Upper West Side of Manhattan. By the time it is completed in the late 1980s more than $1.5 billion will have been spent on this secondary treatment plant. Seventy-five percent of this money is Federal.

Two large tunnels carry water into New York City. These tunnels are old and in dubious condition. They need to be shut down, inspected and repaired. This cannot be done, however, until a third tunnel is built. All of New York's water supply is carried by the two tunnels. If one breaks down, the city receives one half of its water. Everyone agrees that the third water tunnel is more important than the treatment plant. But Congress in 1972 decided that communities—regardless of size or special circumstances or views of local government—had to have, as a minimum, secondary treatment. There is no leeway provided so that a city or community can decide what it needs most to solve its particular problem; the legislation is inflexible.

I repeat, the Federal government provides 75 percent of the cost of constructing wastewater treatment plants. In this case are the Federal funds being spent for the highest water priority for New York City? Or is it time we develop a water program so that we can meet our most pressing needs first?

The Corps of Engineers many years ago did prepare a series of comprehensive river basin reports that were the bases of a water program for each basin to meet the needs of the time. These reports did not deal in the matters of policy but were planning reports that led to a program.

The reports were in response to an item in the River and Harbor Act of 1925 which authorized the Corps of Engineers and the Federal Power Com-

mission jointly to prepare and submit an estimate of cost of making studies of these "navigable streams" whereon power development appeared feasible and practicable. The studies were to formulate general plans for the most effective improvement of such streams for the purpose of navigation and the prosecution of such improvements in combination with the most efficient development of the potential waterpower, control of floods and need for irrigation.

A report listing the streams was submitted to Congress and published as House Document 308; thus the reports became known as the 308 Reports. In the 1927 River and Harbor Act Congress authorized the prosecution of the surveys. In 1935 Congress directed that the authorized surveys be supplemented by additional study to take into account important changes in economic factors as they occurred and additional stream flow records or other factual data.

The Federal Power Commission withdrew from the studies, and in the ensuing 20 years or so from the time of the authorization of the studies the Corps completed almost 200 river basin comprehensive studies. These studies were the first and perhaps the last to develop a water program to meet the needs of the time.

These river basin studies could be updated and lay out a water program to meet the present and future needs of the country.

Another approach to river basin development worthy of consideration was advanced by the Senate Select Committee on Natural Water Resources in the late 1950s. The committee suggested that river basin development for all water users could be achieved through river regulation by including additional capacity in Federal reservoirs. Flows could be released to improve the quality of stream flows during dry periods. This would result in stream flow regulation as part of the water pollution control program. In 1961 Congress included a provision in the Federal Water Pollution Control Act which authorized the incorporation of quality control capacity in Federal reservoirs. The cost of augmentation was to be Federal if the benefits were widespread and national in scope.

The Department of the Army presented a paper on this concept of river regulation in the late 1960s to the Water Resources Council. At that time we were searching for a concept to develop a national water program. It was generally recognized that flow regulations not only improve water quality, but increase water quantity, enhance recreation, improve fish and wildlife habitat,

Our water development is not keeping pace.

We are blessed with sufficient water but we face severe problems of availability and distribution at certain times and in certain areas.

It takes many years to study, plan and construct a project.

increase generation of power, enhance the natural beauty of the river valleys and, most importantly, store waters during times of plenty to be used in times of scarcity.

The effort ran into a snag, however, when agreement could not be reached as to who should pay. Since the benefits were general and could not be specifically tied to single use, we suggested 75 percent Federal and 25 percent non-Federal cost sharing—the same formula enacted by the Congress for the wastewater treatment construction program. This concept was finally killed when the Clean Water Act was passed in 1972, and the buzzwords were you could not substitute dilution for pollution.

Other concepts were considered for river basin planning including Level A, Level B Studies, Comprehensive Coordinated Joint Plans and so on, but none have met with any success because they become too complicated and too cluttered.

What is the solution? I will say that the 308 concept was a good one. Today we have more complex water problems but we also have better tools. I think that one agency should be responsible for the studies but should obtain input from other Federal, state, local and private agencies. We have a wealth of material and a national water assessment as starting ponts. The solution I am suggesting should be in two phases. The first is to develop a program. The Federal water agency that blankets the nation and has the capability to develop the first phase is the Corps of Engineers, and I believe the Corps should be given the job. The Corps should develop a program for the river basins, nothing more.

The second phase, the policy phase, should be developed by another entity. There is no doubt that the Federal government will continue to participate in one way or another in water resources investment. Therefore, the agencies that plan, construct and operate the projects should be members of the group—Army, Interior, Agriculture and perhaps the Environmental Protection Agency. This organization should have an independent chairman appointed by the President and an advisory group representing the states or regions and obtaining input from states, local governments, and regional, interstate and private organizations. The functions of the organization should be to review the basin programs, set priorities, recommend who should build the projects and who should pay, in short make the necessary policies for a total water program. It should in no way get into operation of the Federal, state, local or private agencies. The programs, policies, guidelines and priorities should receive the approval of both the executive and legislative branches of government before

being implemented. It should be the agency that acts as the overall coordinating body. The review function of the organization should be limited to the implementation of the program approved by the executive and legislative branches.

It would appear that the Water Resources Council might be the logical agency to carry out the functions outlined for the second phase. The present council, however, has failed. It has failed for several reasons, the most important of which is that it has been under the exclusive direction of the executive branch of the Federal establishment. In fairness to the executive branch, Congress in passing the 1965 Planning Act did delegate all authority for water resources development to that branch. The only authority Congress retained was to authorize or not authorize a project. In order to develop a program to meet our water requirements, the water agency responsible for the second phase must have a certain amount of independence but must develop policies and programs that must have the approval of both the executive and legislative branches as well as input from state, local and other governmental units if they are going to share the cost.

In the past we have become too concerned with detail but not with a program itself. We spent too much time on benefit to cost analysis, attempting to justify periods of amortization, interest rates, types of benefits, cost sharing and the like. We never considered what the objective or the goal of a water progam should be. We worried about all the details of a project and never considered that a project was a part of a program. I believe if we develop a water program for each of our major river basins, the details that we worried about for so many years would follow.

One final assessment. We are not making full use of our water resources. While our nation and population continue to grow, our water development is not keeping pace. Our economy will surely follow if we fail to produce a program, a direction, an objective to support the adequate development of water supplies to meet the needs of this nation. ■

Flow regulations enhance recreation.

short take

Quenching Hong Kong's Thirst

by Y. L. V. Sharma

To many of the residents of Hong Kong, the dragon, symbol of eternal life and most honored of Chinese pantheistic deities, is also the master of water and rain. According to their belief, floods are caused by movements of the dragon, and sometimes they say they can see him swooping up to heaven in a column of clouds amidst thunder and lightning or dipping his tail into the water where mountain ridges descend into the sea. When the dragon is too quiet, it is said, there is drought. Every summer dragon fights are simulated between colorful boats in the harbor in the hope of inducing a heavenly confrontation accompanied by heavy rains. The charmingly picturesque folk myth has pertinent meaning for Hong Kong today.

The tiny territory has almost no natural resources. Much of the land area is spread over some 230 islands and islets, many uninhabited. The water suppy problem has come from too many people and not enough catchment area. Quenching Hong Kong's thirst has been a continuous challenge. The present efficient water supply system is the result of over 120 years of effort by the government in conjunction with international consultants and engineers.

That system now includes two "reservoirs in the sea," 16 conventional reservoirs, one of the world's largest desalination plants, 14 treatment works, and a third of the total land mass as catchment area. In addition there are tunnels, submarine pipelines, pumping stations, service reservoirs, and a network of mains to distribute the fresh water. A separate system supplies salt water for flushing in the urban areas.

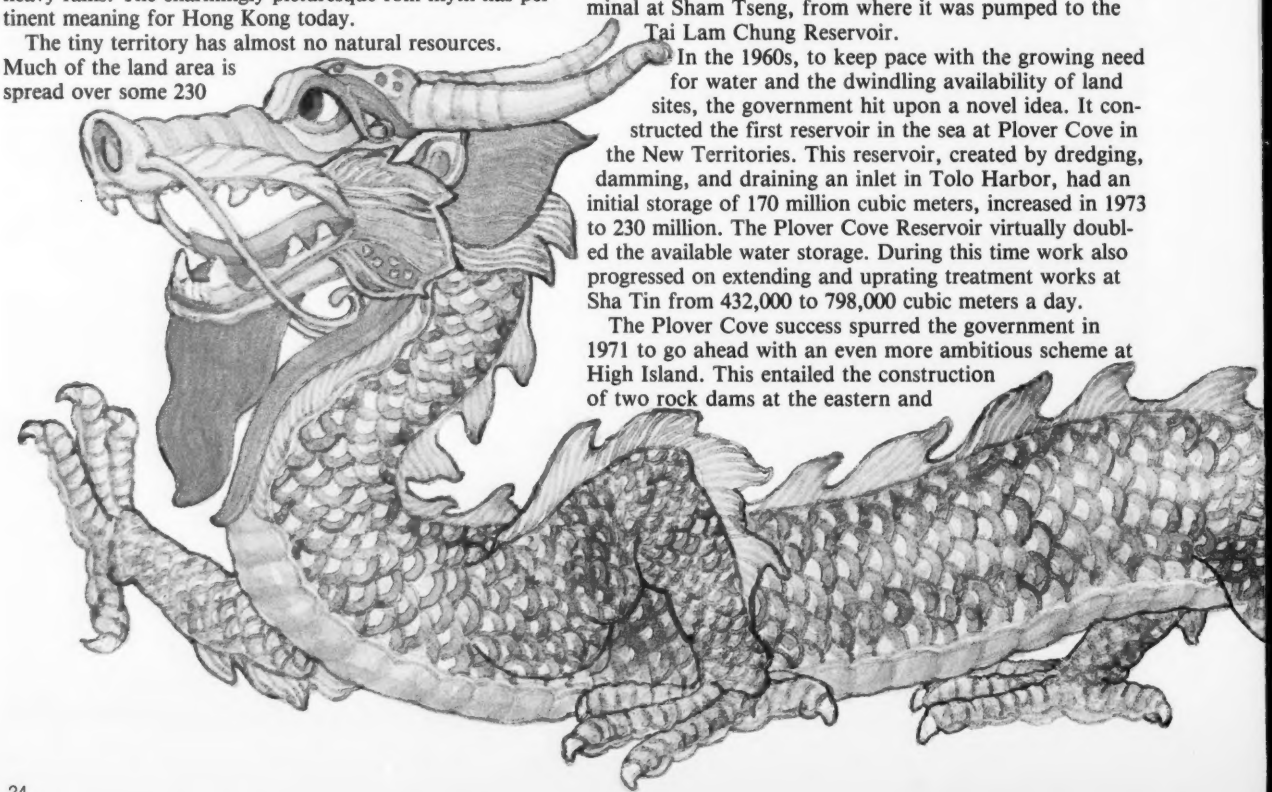
The story of Hong Kong's waterworks began in the 1850s when popular pressure forced the government to recognize its responsibilities for public water supply. In late 1859 Governor Sir Hercules Robinson accepted a proposed scheme to supply Victoria City with water piped from a reservoir at Pok Fu Lam. In 1860 the first construction works were started, and supplies began to reach the city at the end of 1863. A much larger reservoir at Pok Fu Lam was fully operational by 1877.

The rise in population quickly necessitated further schemes and after many problems, mainly economic, the first Tai Tam reservoir project (in the southeast of Hong Kong Island) was completed in 1889. This project gave Hong Kong its first supply of filtered water.

The next 60 years saw the construction of many new reservoirs, but up to late 1967 restricted water supply was the rule rather than the exception. In 1929-30 water had to be imported by lighter from Macau and in 1963-64 by tanker from the Pearl River to a specially constructed terminal at Sham Tseng, from where it was pumped to the Tai Lam Chung Reservoir.

In the 1960s, to keep pace with the growing need for water and the dwindling availability of land sites, the government hit upon a novel idea. It constructed the first reservoir in the sea at Plover Cove in the New Territories. This reservoir, created by dredging, damming, and draining an inlet in Tolo Harbor, had an initial storage of 170 million cubic meters, increased in 1973 to 230 million. The Plover Cove Reservoir virtually doubled the available water storage. During this time work also progressed on extending and uprating treatment works at Sha Tin from 432,000 to 798,000 cubic meters a day.

The Plover Cove success spurred the government in 1971 to go ahead with an even more ambitious scheme at High Island. This entailed the construction of two rock dams at the eastern and



western approaches of a narrow strait running between High Island and the eastern end of the Sai Kung Peninsula. Completed in 1979, the reservoir, with a capacity of 273 million cubic meters, raised the total storage capacity to 579 million.

As part of the continuous search for additional fresh water, eyes turned again to the sea in 1972 and the government decided to construct a desalting plant at Lok On Pai. The first of six units, each with a capacity of 30,000 cubic meters a day and operating on the multiflash evaporation process, came into operation in 1975. By 1977 all units had been commissioned. However, the completion of the High Island water scheme and the favorable rainfall in succeeding years have allowed the plant to become a standby source.

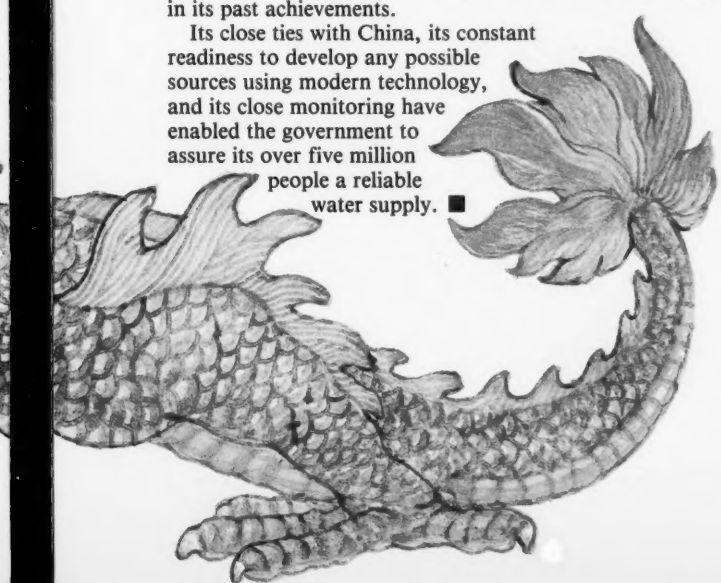
While the territory was developing its own water sources it also looked to its giant neighbor, China, for help. On November 15, 1960, an agreement was made with the People's Council of Po On County under which 22.73 million cubic meters would be bought annually from their Shum Chun Reservoir. This agreement carried a minimum rainfall clause, and during the drought year of 1963 the quantity was substantially reduced.

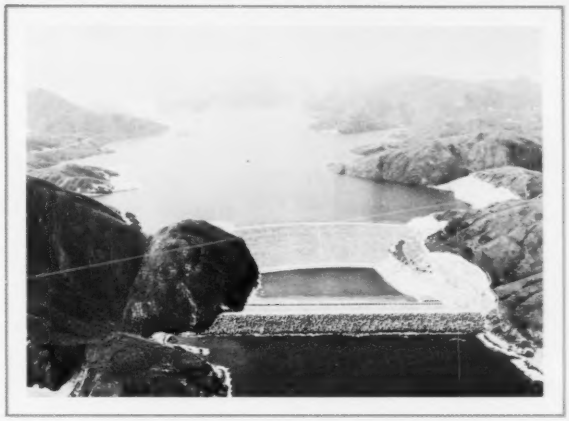
Other agreements to provide additional water were negotiated in 1964, 1972, 1976, and 1978. The latest, made in May 1980, ensures sufficient water supplies for Hong Kong with an average annual increase in supply of about 35 million cubic meters from 1983. This means that China will be supplying 620 million cubic meters per annum by 1995.

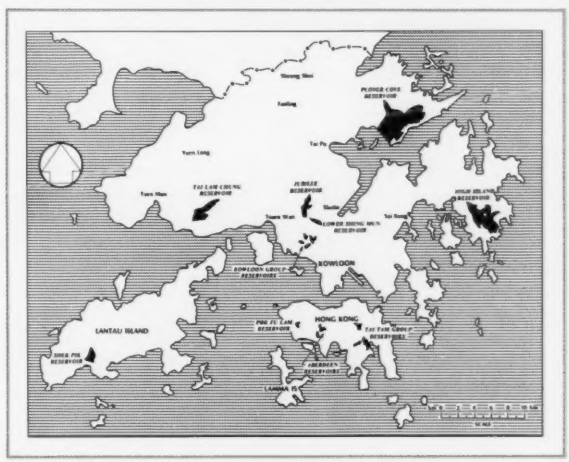
The Chinese authorities extract the water from the East River in Guangdong Province and pump it over a series of dams built across one of its tributaries. The water flows reverse to the natural flow of the tributary and eventually discharges into the Shum Chun Reservoir before being fed by pipeline across the border at Muk Wu to Hong Kong. During 1980 water from China represented over one third of the total demand.

The demand for fresh water has increased steadily over the years; in 1979-80 the daily average was over 1.3 million cubic meters. By 1995 the projected demand will be 1,022 million cubic meters per annum. While this large demand would be a challenge to any water authority in a similar sized area, Hong Kong can at least face it with confidence in its past achievements.

Its close ties with China, its constant readiness to develop any possible sources using modern technology, and its close monitoring have enabled the government to assure its over five million people a reliable water supply. ■



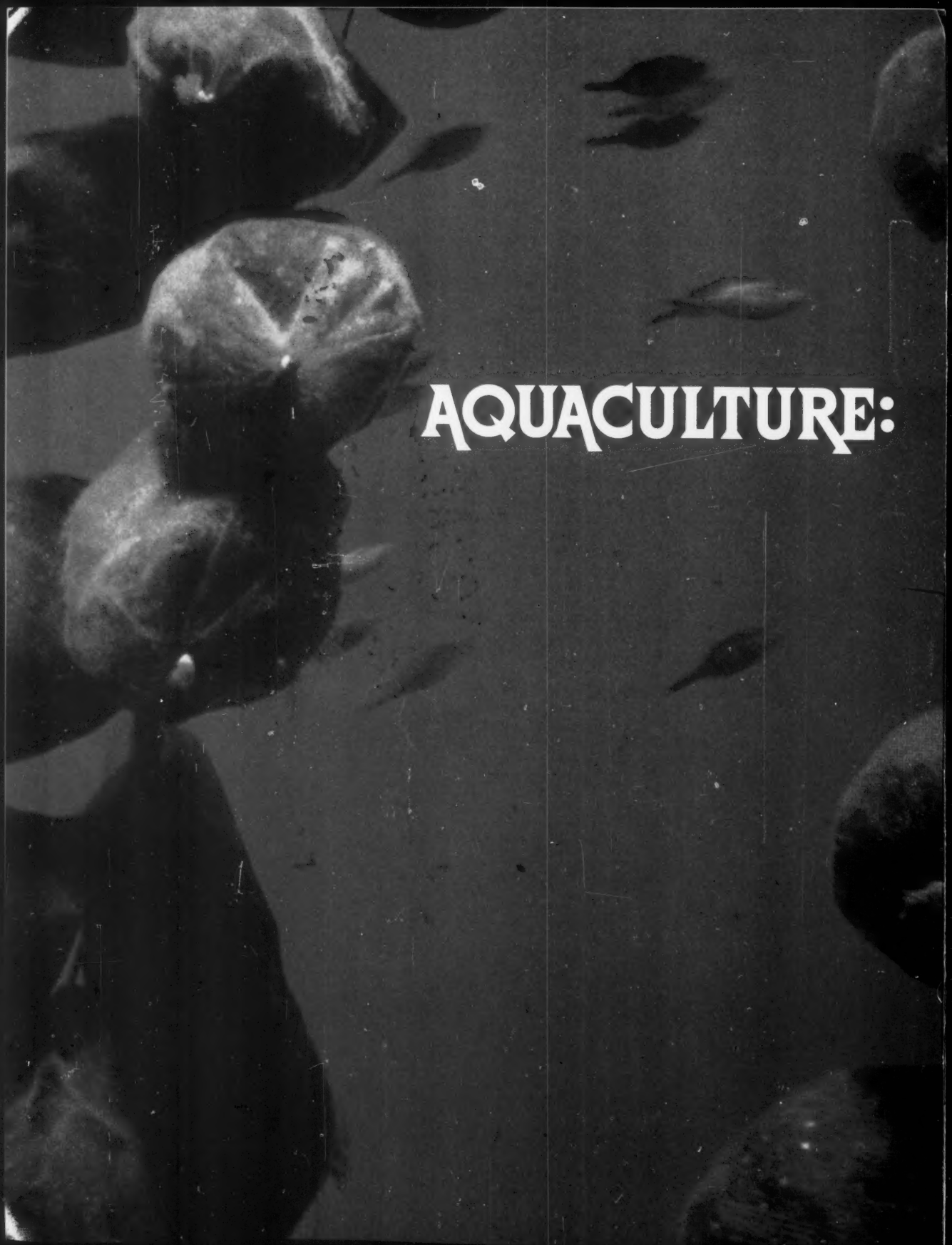




TOP: The Plover Cove reservoir. This was created by dredging, damming and draining an inlet in Tolo Harbor. Storage is now 230 million cubic meters.

MIDDLE: The High Island reservoir. Two rock dams block the eastern and western entrances of a narrow strait running between High Island and the eastern edge of the Sai Kung Peninsula. The reservoir has a capacity of 273 million cubic meters.

BOTTOM: Hong Kong's reservoirs.



AQUACULTURE:

Developments in East Asia

by Daniel J. Sheehy and Susan F. Vik

Beneath the surface of coastal and inland waters throughout East Asia thrives an increasingly important and rapidly growing industry that contributes significantly to the region's food resources. In some areas, colorful floats mark the mass production of oysters and scallops. In others, abalone are spawned according to precisely calculated timetables. In still other areas, computerized monitoring makes the most efficient use of aquatic resources.

Recent advances in engineering, biology, and management have transformed traditional aquaculture into a complex industry capable of supplying an expanding variety and volume of marine products. At the forefront of aquacultural development in East Asia are Japan, the Republic of Korea, and Taiwan.

Aquaculture has a long history in East Asia. Carp culture is believed to have begun in China more than 3500 years ago and to have become a popular practice by about 1000 B.C. Until recently, however, several major problems inhibited growth: the need to ensure availability of a stable supply of seed organisms, to expand areas suitable for cultivation, to cultivate new species, and to solve disease and nutrition problems.

Although progress toward resolving some of these problems began as early as the 1950s, the rapid technological advances of recent years were stimulated during the early 1970s by two events—the oil crisis and the adoption by many countries of 200-mile extended jurisdiction statutes—which affected the distant-water fisheries of Japan, the Republic of Korea, and Taiwan. Because of their dense populations and relatively limited agricultural land, there countries have traditionally relied upon the sea for a significant portion of their animal protein. The Japanese, for example, obtain more than half their supply of animal protein from the sea and have the highest annual per capita consumption of fish and shellfish in the world—165 pounds per person. Each of these countries developed a large deep-sea fishing fleet to feed its population and provide revenue through export of surplus catch or selected high value species. Rising costs and decreasing availability of distant-water fishing opportunities resulted in an urgent need to increase the productivity of coastal and inshore waters.

Current biological research and engineering developments have begun to solve a number of the problems that formerly inhibited aquaculture. For example, reliable methods of artificially spawning abalone and prawns have been established. The efficiency and effectiveness of collecting scallop spat have also been greatly improved. Continuing biological research has brought additional species from experimental to production stages. Culture techniques for abalone, eels, prawns, mullet, and sea bream have advanced rapidly through applications of this research.

Dr. Sheehy is a marine biologist with Aquabio, Inc., of Belleair Bluffs, Florida 33540; Dr. Vik is a technical writer in Columbia, Maryland 21045.

Mesh bags collect scallop spat for culture off Hokkaido, Japan. (Photos courtesy of Aquabio, Inc., unless otherwise noted.)

Large tetrapod breakwater used to create sheltered culture areas.
(Photo courtesy of Nippon Tetrapod Co., Ltd.)

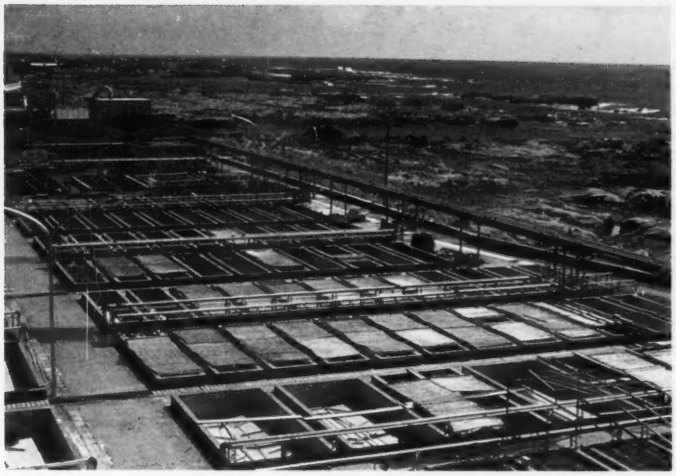
Floating breakwater used to develop a culture area in the outfall of a nuclear power plant in southern Japan.

Engineers have expanded the areas suitable for aquaculture by developing deep water longline culture methods for scallops and oysters and artificial nurseries for abalone and shrimp. Projects to construct breakwaters and improve water exchange through channel modifications have also contributed to making new areas available. Improved pollution control methods have helped to restore areas previously unsuitable for culture.

In addition, improved mass culture methods for efficient food organisms such as chorella and rotifers have helped reduce hatchery costs. Better techniques for monitoring and treating disease have also made such ventures less risky, and insurance coverage is now available for a broader range of projects. Although problem areas still exist, they are yielding to intensive research.

A wide variety of methods is used to culture the principal marine species in Japan, Korea, and Taiwan. Sessile organisms such as bivalve mollusks (oysters, clams, scallops) are cultured on the ocean bottom, on sticks or racks fixed in intertidal areas, or from rafts or longlines anchored in deeper water. The current longline method uses either surface or midwater floats and greatly extends the areas under cultivation by making full use of the water column as well as by opening areas which are either too deep or too exposed for other culture methods. The more mobile species of fish and crustaceans (prawns or shrimp) are cultured in ponds or tanks, floating cages, or pens usually located in embayments or protected areas. Some mobile species such as salmon and abalone, as well as shrimp and other fish, are also stocked in open areas and eventually captured by traditional coastal fishing methods. This technique, known as ocean ranching or extensive culture, is expanding, especially in Japan where an integrated program of stocking, habitat improvement, and close management has led to rapid progress in productivity and cost-effectiveness.

The expanding aquacultural industries in Japan, Taiwan, and Korea are supported by private, university, and government research. Although location and technology transfer have engendered similarities among their aquacultural programs in terms of species cultured and techniques used, there are also differences arising from local customs, marketing channels, and economic conditions. The objective also varies between and within countries; it may be to provide a premium product for the domestic market, an inexpensive staple for domestic consumption, or a product for the foreign market. Objectives are changing as the countries' economies continue to expand, especially in Taiwan and Korea where domestic demand for premium species or sizes is growing and less are being exported to Japan, Hong Kong, or the United States.



Abalone hatchery in Chiba Prefecture. Juvenile abalone are reared to stocking size in outside tanks.

JAPAN

The principal marine species cultivated in Japan for consumption are yellowtail; Kuruma prawn; Japanese oysters; scallops; sea bream; and three algae, Nori, Wakame, and Konbu. A large volume of pearl oysters is also cultured, but they are not used for food.

Earlier aquacultural work in Japan concentrated on the basic reproductive biology of the important species and the development of hatcheries for the mass culture of juveniles. Although this work was generally successful, the cost-effectiveness of the stocking programs came into question because the fate of stocked juveniles was quite variable. Efforts to expand basic ecological knowledge have improved stocking strategies that have increased the return when used in ocean ranching.

The current aquacultural program has developed into an integrated effort that includes intensive pond, cage, pen, raft, and longline culture. In addition, ocean ranching has been expanded to include both stocking and habitat improvement.

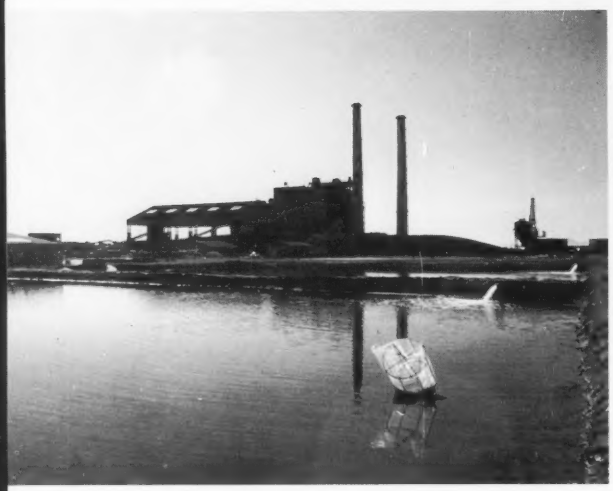
A variety of engineering projects has also contributed to the current efforts to improve the culture grounds. These projects include the development of traditional and floating breakwaters to create protected areas for culture, special tidewater stocking areas for Kuruma prawn, and special nursery grounds for a variety of fish and shellfish. In addition, the carrying capacity of several areas has been increased by the creation or enlargement of channels to improve flow conditions.

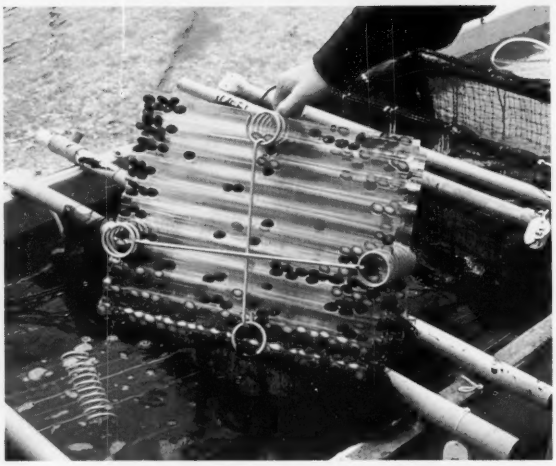
ABALONE

Abalone is a high-value species cultivated for domestic consumption in Japan. Great technological progress occurred during the past decade when earlier biological studies on abalone spawning and larval development combined with breakthroughs in controlled methods of artificial spawning to pave the way for the current development of this premium marine resource. Abalone culture is now conducted through a highly integrated, comprehensive program combining hatcheries, stocking, habitat improvement, and resource management.

Artificial spawning techniques were developed after Japanese researchers discovered that water passed through ultraviolet sterilizers served to stimulate preconditioned abalone to spawn. By using this technique, hatcheries can

RIGHT: *Cultured abalone at Mohne Bay, Japan. Abalone feed on diatoms and algae which grow on the plastic plates.*





LEFT: Thermal culture of ayu in Omura, Japan. Warm water is used to increase growth rates and maintain species beyond normal season. Here, water from a conventional power plant is used.

induce mass spawning under artificial conditions. Production volume and scheduling can now be controlled to maximize the capacity of hatchery facilities.

Over 30 abalone hatcheries are currently in operation in Japan, and a number of these produce more than a million 20 to 30-mm. juveniles annually for stocking. To increase production efficiency, several of these hatcheries use thermal effluent water from conventional and nuclear power plants; this use not only produces a greater number of abalone per year but also turns a potential environmental liability into an asset. A hatchery in Hokkaido actually uses geothermal warm water passed through a heat exchanger to increase the growth rate of spawned abalone.

Earlier efforts to stock juvenile abalone were aimed primarily at conserving the resource, which was subject to heavy fishing pressure. Because of the relatively abundant supply of juveniles now available, an extensive ocean ranching program has been put into effect. Juvenile abalone are sold to local fishermen for stocking, generally in areas controlled by a fishermen's cooperative which regulates fishing and access to the ground. Initially, stocking efforts were successful in some places, but it quickly became apparent that the availability of shelter and food limited the carrying capacity of many locations and that even in some natural nursery areas juvenile mortality was increased by wave conditions. A program to improve abalone habitat for both stocked and naturally spawned juveniles as well as adult populations has been undertaken. Today, a wide variety of artificial reefs and other structures specially designed to provide shelter have been installed to promote food growth and stabilize the natural environment. (*See Dr. Sheehy's "Fisheries Development: Japan," in the Winter 1979–1980 issue of* Water Spectrum.)

One of the most ambitious of these habitat improvement projects involves using an integrated resource management approach to convert "marine deserts," barren areas along the coast capable of supporting only sparse communities, into more productive areas. Biologists have identified several factors which cause these marine deserts: colonization by (calcareous) algae, heavy wave action on the rock substrate, and intense grazing pressure by herbivores such as sea urchin. The result of these conditions is a reduction of the standing stock of macroalgae essential for maintaining abundant abalone populations. The Tohoku Regional Lab has initiated a special type of off-the-bottom longline culture of *Laminaria* (Konbu) to re-establish macroalgal populations in areas depleted by sea urchins. This technique protects the parent plants and has led to repopulation of the areas. By carefully managing both the sea urchin and abalone populations through control of fishing activities, biologists converted the marine deserts into productive areas.

A distinctive color variation present on the shells of hatchery-raised abalone but absent on those naturally spawned allows the survival rate of stocked juveniles to be determined with considerable accuracy. It has risen to over 40 percent in some areas. Because

Artificial reef for abalone used to expand habitat and create nursery areas. (Photo courtesy of Asahi Chemical Industry Co., Ltd.)

Dr. O. Sato of Hokkaido University inspects net cages suspended from longlines. (Photo courtesy of Dr. Sato.)

of this high rate of success, the habitat improvement program for abalone has been expanded.

SCALLOPS

Scallop culture has made remarkable progress in Japan since the mid-1960s. The development of new techniques for collecting seed scallops and the implementation of hanging culture methods have been responsible, in part, for almost doubling the world production of scallops. Current Japanese production exceeds 100,000 tons, of which more than half can be attributed to new culture techniques.

Earlier scallop culture efforts were generally limited to collecting and transplanting scallops from one area to another for restoration or development of new beds by means of bottom culture. In several areas off Hokkaido, for example, stocks had declined from overfishing and starfish predation, and new management methods were instituted. An integrated program to remove starfish, stock more than 10 million seedlings, and ensure through monitoring that enough adults remained to sustain the population restored the fishery to a productive level. In bottom culture, however, production is limited by the amount of suitable bottom available.

The use of hanging culture techniques, in which a series of net baskets is suspended well below the water surface, has permitted a rapid expansion in production. The limits to production are spat availability, water conditions, and legal restrictions based upon estimates of local carrying capacity. By taking advantage of the three-dimensional properties of the water column, hanging culture uses available resources efficiently. Engineering research has resulted in stabler, more wave-resistant longlines which serve to expand offshore the areas suitable for culture. When used in deep water, the hanging culture system has few surface floats to interfere with navigation and does not conflict with other water uses.

The general culture technique currently in practice involves the use of small synthetic bags with small sections of fishing net to collect naturally spawned scallop spat as they settle from their planktonic state during the spring. The seed scallops thus collected are reared in these suspended bags to an intermediate size of three to six centimeters, and then either are released at appropriate bottom sites for eventual harvest by trawlers or are hung in cages or on strings where they are grown to market size.

Scallop culture is practiced primarily off Hokkaido and Aomori and along the northeast coast of Iwate. Very dense culture occurs in Mutsu Bay, Aomori, where virtually all of the scallop catch is attributed to hanging or bottom culture. This bay is an ideal natural collecting area for spat and has an estimated water turnover time of 100 days. On occasion, very large concentrations of natural spat can be collected; these are used as seed to support both local and distant culture programs. Seed from a scallop (*Patinopectin yessoenis*) prevalent in Aomori are collected and used in hanging culture projects in areas beyond that scallop's natural range.

Hokkaido fishermen place scallops in culture cages.

Remote environmental data collection buoys monitor the area and provide daily information on temperature, salinity, dissolved oxygen, and current direction and speed. These data are processed through a computer base station and are used to help predict scallop spat collection times as well as to provide early warning of critical conditions that could affect production.

Despite rapid increases in production, the scallop culture industry in Japan has also experienced severe problems from shellfish poisoning, high density culture conditions, and other factors not yet clearly identified. At times, losses in some areas have reached almost 100 percent, and fishermen have suffered accordingly. However, the establishment of density limitations, improved handling and seed selection, and closer inspection of scallops before shipment has helped reduce these problems.

REPUBLIC OF KOREA

Korean aquacultural production has been growing steadily and has risen from about 40,000 metric tons in 1962 to over 350,000 in 1975. The 1975 figure accounts for about 17 percent of Korea's total fisheries production and about 8 percent of its total fisheries exports. Aquacultural production plays an increasingly important role in the economy.

Of Korea's approximately 103,000 hectares of tidal and coastal area suitable for aquaculture, more than 45,000 are currently in use. The main species cultured in Korea are oysters, hard clams (*Meretrix*), cockles and ark shells (*Anadara*), and a variety of edible seaweeds (Laver and Dulse).

The Korean government has made substantial investments to promote aquacultural research, improve management methods, and develop long range plans to ensure continued success and expansion.

Harvesting oysters in Chungmu. Note string of oysters at left.

Hanging oyster culture area in Chungmu, Korea.

OYSTERS

Oysters (*Crassotrea gigas*) have generally been the most important aquacultural product in Korea in terms of volume and value. The major portion of oyster culture activities occurs in the Chungmu area where about 15,000 metric tons are produced annually, principally for export in canned form to the United States and Canada, in dried form to Hong Kong, and live or frozen to Japan. More than 2100 hectares are under cultivation, primarily with longline techniques that provide a yield of over seven metric tons per hectare.

The longline techniques currently in use have been developed from earlier culture methods, including sticks stuck into the bottom to collect spat and wooden frames restricted to use in shallow water. Raft culture methods greatly increased the potential culture area but were limited to use in protected locations. Longline methods, which weather storms better, have permitted further expansion of the grounds.

Although the program in Chungmu is considered quite successful, some significant problems have arisen. Some of the fishermen who now operate longer vessels wash oysters on site before transferring them to processing plants. Pollution has resulted, and the local fisheries research and development agency has stressed the need to wash at the processing plant where settling ponds prevent pollution. It is also believed that the Chungmu area has almost reached its carrying capacity and that current densities may already be too high for optimum growth.

Several natural problems are also associated with high density culture, among them oyster drill disease and red tides. The oyster drill disease can now be controlled by submerging the oysters in 50-degree Celsius water for five minutes. Red tide, occurring mainly during the spring and summer, has been more difficult. Despite good circulation in the Chungmu area, red tide has become a regular problem; in 1973, almost 80 percent of the harvest was lost. Red tide prediction and monitoring are high priority items in the current research program.

To ensure quality products, especially for the expanding export market, oyster sanitation is important. Bacterial levels in the oysters, water, and sediment are monitored at least monthly at more than 32 sampling stations to make sure that conditions are within the range of acceptable sanitation limits.

Small boat pushes a net used to collect milkfish fry off the coast of southern Taiwan.

Milkfish culture pond with a small enclosed area in which fry adjust to conditions before entering main pond.

TAIWAN

Taiwan's involvement with aquaculture dates back to early mainland Chinese work. During the last 20 years, Taiwan had made rapid progress by updating earlier culture methods, adding new species (both endemic and foreign), and applying the results of research to increase production levels.

Aquaculture accounts for about 16 percent of Taiwan's fisheries production. Principal species cultured include milkfish, carp, tilapia, oysters, eels, clams, mullet, and prawns. Taiwan realizes very high yields per acre of harvest from the application of polyculture methods and good management techniques. Recent advances have been made in the production of mullet, freshwater prawns (*Macrobrachium*), and saltwater prawns (*Penaeus*); new developments in open sea culture of abalone are in progress.

MILKFISH

Milkfish has traditionally been Taiwan's top aquacultural product in terms of total weight and is second in value only to eels. Its primary use is as a moderately priced staple for domestic consumption. Although Taiwan has a three month winter period during which milkfish do not grow and it generally has smaller farms than in the Philippines and Indonesia, it has a higher production per hectare, ranging up to 2500–3000 kilograms per year, than the others.

Principally a herbivorous marine species, the milkfish is generally cultured in brackish and freshwater ponds where it feeds on diatoms and algae growing on the pond bottoms. The fishery still depends upon wild fry collected along the coast with hand or small boat nets and then stocked into ponds ranging from one to six hectares in area. Water depth varies according to the size of the fish and ranges from six inches to four feet.

The ponds are carefully managed to ensure optimum conditions. The management process includes annual drying, fertilizing, liming, and treatments to eliminate insect larvae and pest fish. Water flow and salinity are carefully regulated. Stocking levels depend upon the amount of benthic algae which can be supported.

Milkfish culture area in southern Taiwan.

Indoor tanks where larval prawns are reared.

Although milkfish culture continues to be successful in Taiwan and other areas off Southeast Asia, several problems have arisen to slow the growth in production. The main one stems from the dependence upon wild stocks of fry; their availability fluctuates and is at times unpredictable. Research aimed at closing the life cycle of the milkfish is underway at Tung Kang and other labs. Other problems concern the maintenance of appropriate pond salinity and food levels. Stocking densities are reaching the capacity of the ponds, and supplemental feeds may be required to increase stocking levels beyond those currently in use.

PRAWNS

Relatively recent developments in the artificial propagation of marine prawns in Taiwan have led to the very rapid development of the culture industry for these species. While prawns have been cultured for some time, earlier methods depended upon natural stocks of postlarval prawns introduced with pond water influx or collected along the coast in nets and stocked. Artificial propagation of grass prawn (*Penaeus monodon*) spawners was first achieved in 1968. This breakthrough has increased prawn production from 57 tons in 1967 to 3200 tons in 1979.

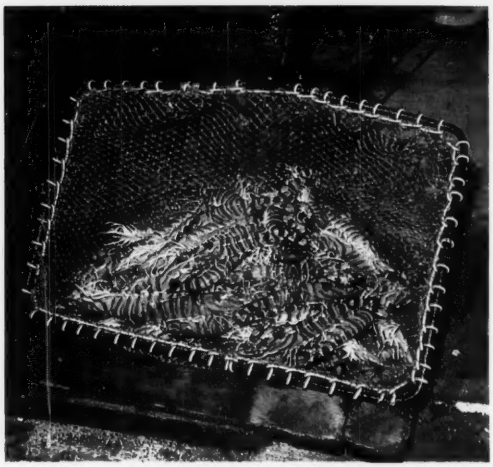
Over 200 private prawn hatcheries in Taiwan currently produce more than 300 million postlarvae per year. The scheduled availability of seed prawns has served to change the culture practice in most areas from extensive polyculture (with milkfish and crab) to intensive monoculture. The major problem now being researched concerns the cultivation of spawners (the current method uses collected spawners, which have greatly increased in value).

The grass prawn has a number of characteristics which make it particularly suitable for culture. With an average market size of over 100 grams, it is one of the largest penaeids. It is a hardy species, able to tolerate a wide range of water temperatures and salinities. It also grows quickly, feeds on both plant and animal matter, and does not require a sand bottom as does the Kuruma prawn (*Penaeus japonicus*).

Gravid females are brought to the hatchery and spawned. After hatching, the larvae are transferred to indoor tanks and fed a controlled diet, with the exact composition of the feed determined by the larval stage and the available food supplies. In about five days, they molt into the post-larval state and their diet is expanded. At about 20 days after metamorphosis, they are stocked into ponds and are grown to market size, generally around 40 grams. Two or three crops can be raised each year, depending upon location.

Although the current annual yield of 1000–1200 kilograms per hectare is considerably less than that in milkfish or polyculture projects, the high prices commanded by this species make its culture quite profitable. Planning is now under way in Taiwan to begin artificial seeding in coastal waters, as already practiced in Japan, to further increase production.

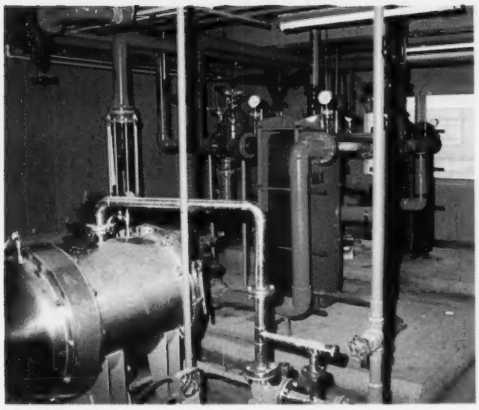
Prawn culture: earthen ponds with a centralized irrigation system.



Cultured prawns ready for the market.

AQUACULTURE AND THE WORLD FOOD SUPPLY

Aquaculture worldwide currently accounts for over six million metric tons, roughly 10 percent of the annual world fisheries production. Most informed predictions, such as those made by the United Nations Food and Agricultural Organization, estimate that the current production levels could be increased significantly by the end of this century. This would provide developing countries with a relatively inexpensive source of animal protein and income from the export of high value products to developed countries, which could also benefit by expanding their own aquacultural industries.



Heat exchanger used at a geothermal warm water abalone hatchery in Hokkaido, Japan. The warm water increases the growth rate of cultured abalone.

Women divers of Chejudo, Korea. In many areas of Japan and Korea, this is the method of abalone harvest.

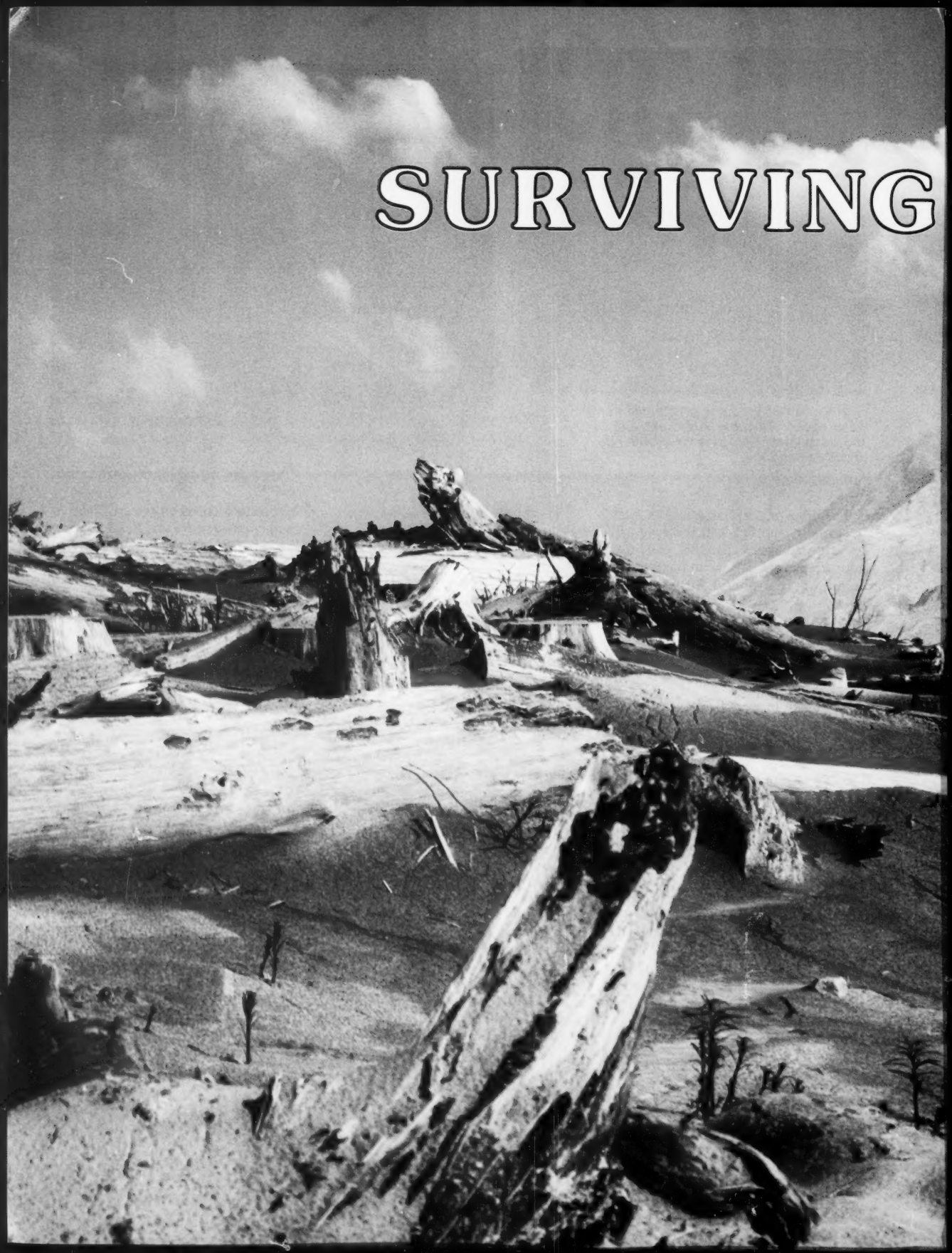
The price of seafood products is rising rapidly, and the costs involved with traditional capture fisheries have also gone up as fuel, labor, and equipment costs increased while legal restrictions have limited access to many of the most productive grounds. In addition, current estimates suggest that the supply of fish from conventional sources is limited to about 150 million tons per year, of which about 40 percent is currently being harvested. As more fleets compete for a limited resource, the catch per vessel will decline.

These factors serve to make aquaculture, at least conceptually, a very appealing prospect. The peoples of East Asia have a long tradition in this area, and their well-organized and well-funded national research and development have contributed to the recent progress and have begun to stimulate growth elsewhere. In particular, Southeast Asia has, with the aid of technology transfer support from such agencies as the South East Asian Fisheries Development Center, quickly expanded and developed its own traditional aquacultural techniques.

Technology transfer of these methods could contribute to feeding the world's growing populations. However, introduced technology must be appropriate in terms of cultural, socioeconomic, and environmental conditions in the countries involved. At the present time in East Asia, an unusual mixture of twentieth century technology and traditional practices coexists in some aquacultural industries. Abalone culture in Japan, for example, combines the most modern hatchery practices of rearing abalone with harvesting methods which in many areas are almost the same as those in use for centuries.

The Chinese have an old saying: "If you give people fish, they will have fish for one day; if you teach people to raise fish, they will have food for a lifetime." Although many problem areas still must be resolved, the coordinated biological, engineering, and management efforts currently underway in Japan, Korea, and Taiwan hold promise for the future development of the aquacultural industry around the world. ■

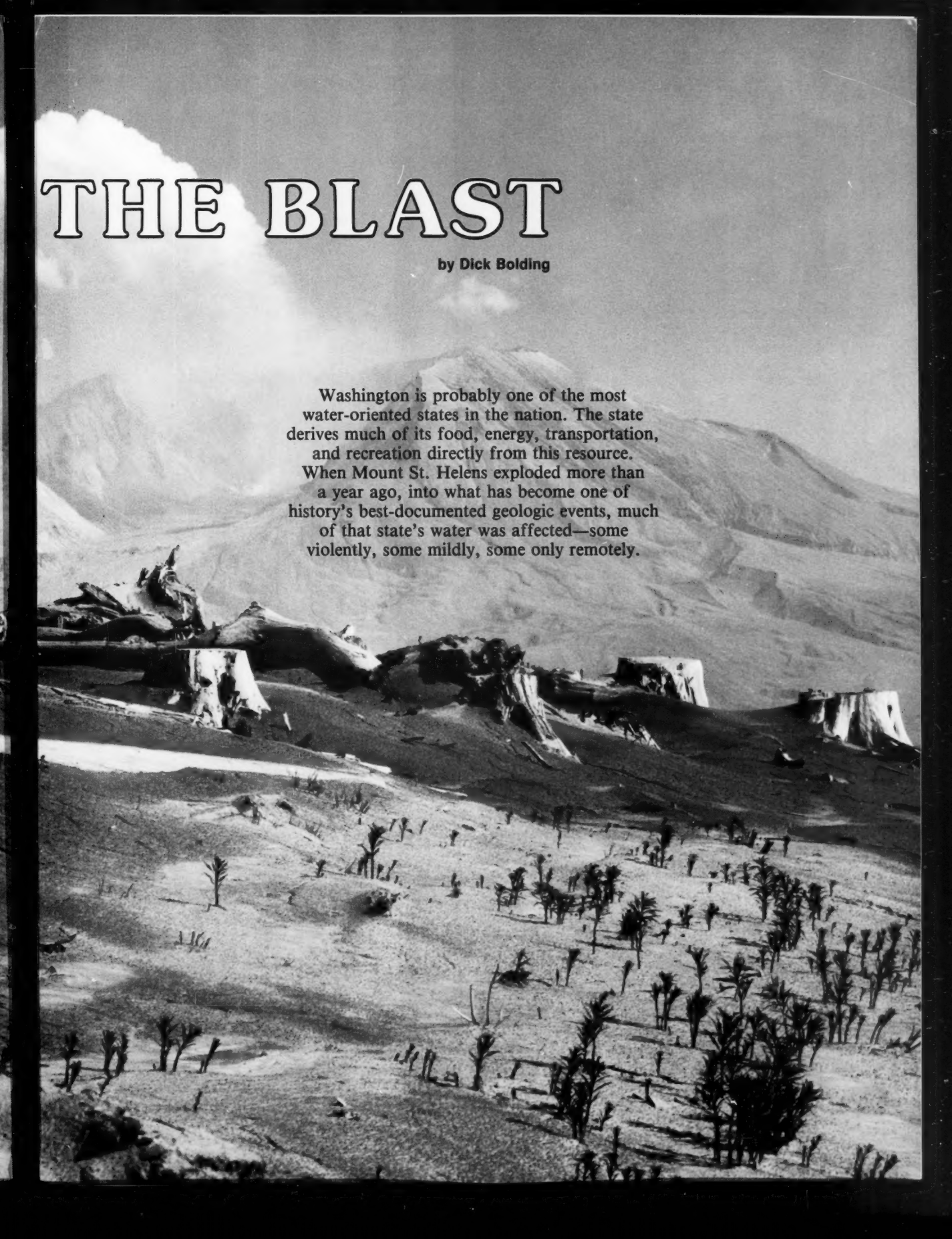
This article is based on research trips to Japan sponsored by the Japan Society for the Promotion of Science, to Taiwan sponsored by the Institute of Zoology at the Academia Sinica, and to Korea assisted by the Fisheries Research and Development Agency. Dr. Sheehy expresses his deep gratitude to Dr. Takashi Ino of Japan, Dr. Kun-Hsuing Chang of Taiwan and Dr. Choong-Kyu Pyen of Korea, whose assistance made this research possible.


SURVIVING

THE BLAST

by Dick Bolding

Washington is probably one of the most water-oriented states in the nation. The state derives much of its food, energy, transportation, and recreation directly from this resource. When Mount St. Helens exploded more than a year ago, into what has become one of history's best-documented geologic events, much of that state's water was affected—some violently, some mildly, some only remotely.



SURVIVING THE BLAST

As reports rolled in from reconnaissance over the May 18, 1980, blast area, the only "given" was that conditions were worse than anyone had imagined. Everyone had viewed television news films that documented the awesomeness of the event, but few could grasp the scale of what they were seeing. Wildlife workers were quick to get to the Toutle River, one of the few places they could reach, and they like others were shocked to witness the forces of destruction in process. The river was a complete loss, so it was not hard for fish biologists to accept the report that 26 of the high lakes within the St. Helens blast zone were destroyed.

Since that time technicians have been able to actually visit these scenes of desolation and have found the monochromatic vista not quite as devoid of life as originally thought. Biologist Bruce Crawford said he couldn't adequately describe his first visual impression. The area just appeared as a vast, sterile wasteland. But as he began to probe some of the key lakes, signs of life became evident. What had happened?

Geologists described the initial hurricane-like concussion wave as one laden with a variety of material from the volcano. Rocks, ash, pumice, and new rock from within the mountain were blown north, northeast, and west six and a half to eight kilometers, while the less heavy load of super heated sandy ash shotgunned out another eight to 22 kilometers, depending upon topography. High temperatures were evidenced by burning trees, scorched roots, singed hides of a band of elk found dead 16 kilometers to the northwest, and melted plastic on a camper truck near Ryan Lake, 11 kilometers northeast of the peak.

There is some speculation as to what happened to the water within the lakes. Spirit Lake, located directly below the north side of the mountain, was completely changed by being filled with material from the volcano and then trees on top of that. The rapid temperature change of the cool lake water to near boiling and sedimentation alone were enough to eliminate fish life. Much of the lake water was probably displaced and then replaced with runoff from the volcano, so it seemed likely to Game Department biologists that other, smaller, lakes would have sustained similar devastation. However, most other lakes within the blast zone seemed to have fared considerably better.

Aerial view of Elk and Hanaford lakes after the eruption. Twenty-six lakes within the zone of destruction were thought to have been destroyed. (Photo by Austin Post, U.S. Geological Survey.)

Shultz Creek basin during an early winter rainstorm. In this treeless topography of the St. Helens blast zone, water runs downhill off everything when it rains.
(Photos by the author unless otherwise noted.)

Mr. Bolding is an information officer with the Washington State Department of Game, Olympia 98504, and is associate editor of *Washington Wildlife*. His "After the Blast," in the Spring 1981 issue of that magazine, dealt with the condition of the lakes within the Mount St. Helens blast zone a year after the cataclysm. This *Water Spectrum* article expands upon that topic and addresses how the lakes weathered the winter.

Pearly everlasting, bracken fern, and fireweed dominate the new growth in many places. Other plants in the background are Oregon grape and thimbleberry.

Twenty kilometers north of St. Helens in the Green River drainage, pearly everlasting adds a little greenery to the ash-covered hills. In this area trees are broken, blown down, defoliated, and dead from the blast heat wave.

An ash-covered clear cut north of St. Helens with a vigorous growth of Canadian thistle and pearly everlasting (white blossom).

SURVIVING THE BLAST

Evidence of the destruction began to indicate that wind velocities must have been terrific under the blast cloud. At Tradedollar Lake, 17½ kilometers northwest of St. Helens, a truck was rolled some 90 meters from where it had been parked. Many lakes had nearby trees hurled into them. A search party at Fawn Lake, 15 kilometers northwest of the mountain, found fish remains a considerable distance from the lake—an indication that water had been displaced. Most lakes probably experienced some violent wave action and smaller ponds may have had water blown out of them, but such was not the case in most instances.

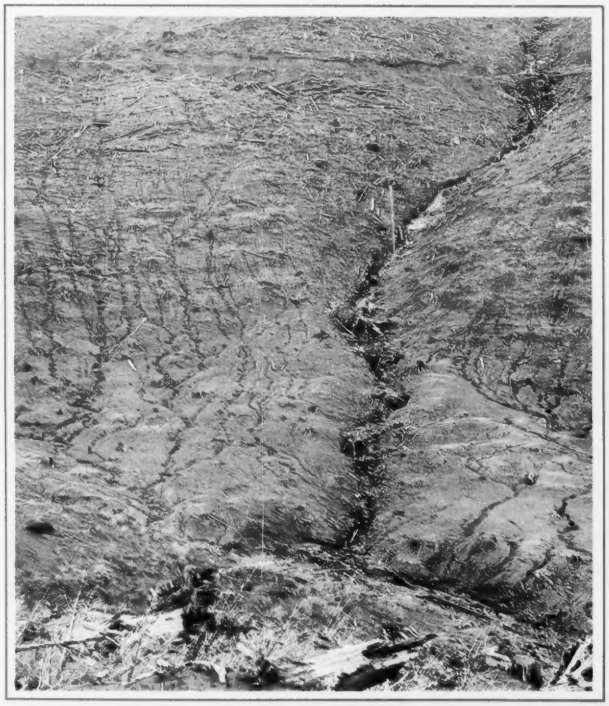
The single occurrence that affected lakes most and had a direct bearing on the fish was the showering of material from the mountain. How long this went on is not known, but lakes closer to St. Helens no doubt received a fairly continuous deposition of rocks, sand, and ash throughout the eruption. Lakes beyond eight kilometers received mainly sand-sized and finer ash. Ash was the villain that destroyed both terrestrial and aquatic insects upon which fish feed. High densities of ash suspended in the water also abraded fish gills and may eventually result in mortality.

Biological survey teams were able to make preliminary investigations of several high-country lakes early last summer. Their hopes rose when they discovered basic food chain organisms still thriving even though on a much reduced level. At Meta Lake, about two and a half kilometers east of rearranged Spirit Lake, the team found a surface temperature of 68 degrees Fahrenheit and the water dark but clear. Dissolved oxygen, pH and water hardness were normal. They fished the lake with spinning tackle and got no response, then walked the outlet creek and saw no fish. Finally they electrofished over 100 yards of shoreline and located only three crayfish but found numerous food source organisms (a good omen for the recovery of the lake). The ground around the lake was covered with 10 centimeters of compact ash and a blanket of pumice chunks as large as 10 centimeters in diameter on top of that.

The group returned to Meta at the end of September to repeat the water tests, which again registered normal. This time they set a gill net and left it overnight; next morning they collected 35 eastern brook trout ranging from 15 to 23 centimeters. The fish appeared to be in good condition, with their stomachs full or partly full of insects. Although Meta Lake is only about nine and a half kilometers from St. Helens, a ridge to the west protected it from direct blast damage. Not all lakes were so fortunate.

On an earlier flight north from St. Helens over the Fawn Lakes group, biologist Crawford had looked unbelieving at what lay below. What had been a chain of glistening sky blue mountain lakes had turned to mud puddles in a rolling wasteland of miles of jumbled logs. Later in July the investigators reached these lakes to test water chemistry, measure ground cover and ash depth, and record general observations. At Fawn and Hanaford lakes, skunk cabbage was beginning to grow, as were alder, lily, and alpine fir. A tight 10-millimeter-thick coating of ash-mud covering the lake

On the North Fork of the upper Toutle River, horsetail pushes up through the concrete-like mud flow debris. This hardy plant appears to be growing at most elevations of the blast zone.



Heavy winter rains create erosion patterns down the fall line, continually washing ash into streams, rivers, and lakes.

The upper North Fork of the Toutle River is establishing a new channel through the jumble of ash and material from the volcano. Some adult returning salmon and steelhead have found their way back through the turbid lower river.

Regrowth in the ash-laden hills of a clear cut area north of the volcano first takes root where the ash is thinnest or where it has been eroded away. Thistle, fireweed, and pearly everlasting predominate.

bottom severely restricted aquatic insect production. However, dragonfly, chronomids, copepods, and salamander egg cases were found. No fish were observed at either location, but crayfish and gammarus were seen at Hanaford. Dissolved oxygen and pH tests were only slightly lower than normal.

When the team returned during September to set gill nets, the findings at Fawn and Hanaford were more encouraging. Basic water tests were normal, insect production was still retarded but was improving, and ground cover around the lakes was beginning to green up considerably. Six brook trout and one cutthroat, all fairly large, were caught. Their stomachs contained midge larvae, gammarus, chilopoda, and corixidae. These tiny insects were not as numerous as usual, an indication that insect production was not yet up to average. Although fish populations are undoubtedly low, the specimens examined were in good general condition. None displayed the expected gill damage so prevalent in fish from streams and rivers where water was moving.

Numerous lakes farther away from the immediate zone of destruction were checked in similar fashion and each exhibited a remarkable pattern of normality. Biologists were amazed at how rapidly both terrestrial and aquatic insects were rebuilding their numbers after near annihilation.

As winter storms became more severe and road washouts more prevalent, monitoring operations had to be suspended.

Fish biologist Bruce Crawford retrieves a set net to monitor fish life in Tradedollar Lake.

OPPOSITE: Sedge grass growing in the mud flow of the upper North Fork of the Toutle River valley.

Logging crews work to save Shultz Creek bridge from washing out during a heavy rainstorm.

SURVIVING THE BLAST

Biologists speculated about the possible consequences of this weather and its effects on high lakes. The major concern was for heavy siltation brought on by continual rains. When it rains in that treeless land, water runs off everything. The ash-laden hillsides eventually give way to little riverlets that form endless parallel lines moving downslope and gradually eating away the ash. In some places, depending upon slope, runoff seems to compact the gray mantle; in others, it is a constant erosion factor moving the flour-like ash into streams, lakes, and rivers.

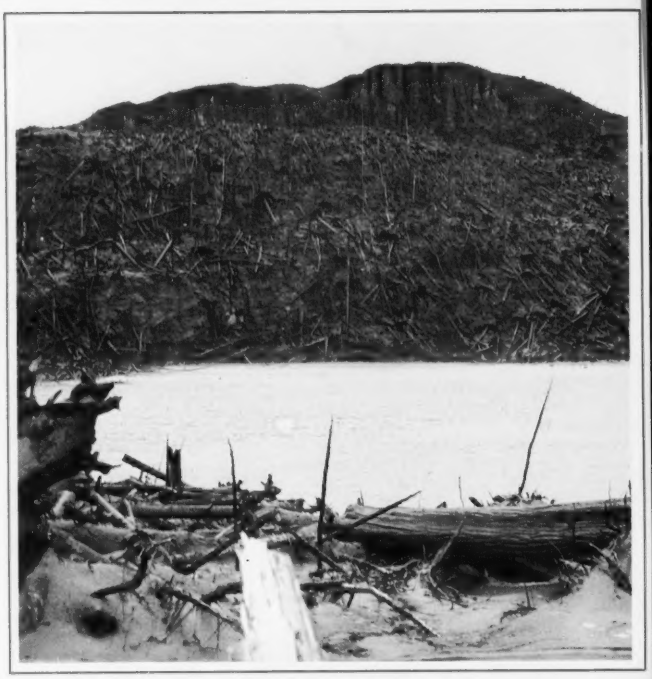
The danger of continuous ash deposition is a real threat to the rebuilding food chain, particularly aquatic insects, as well as to fish. When all other environmental factors are normal, the success or failure of these fish populations depends solely upon their food supply.

A high percentage of fish checked from streams subjected to heavy ash siltation have suffered gill damage. As velocities of this abrasive water increase, the fragile tissue of fish gill filaments is eroded, in some cases resulting in mortality. Someone wading one of these streams can feel the ash abrasion: streambed rocks are not slippery; the customary algae cover has been sanded away. However, fish seem to survive in very turbid lake waters without experiencing this problem. One of the real difficulties they do have is finding food when water visibility is poor. Being visual feeders, fish living in the muddier lakes have to spend more time and energy searching for meals than they normally would. With most of these blast-zone lakes being short on food supply, it is safe to assume that there have been some winter losses from malnutrition.

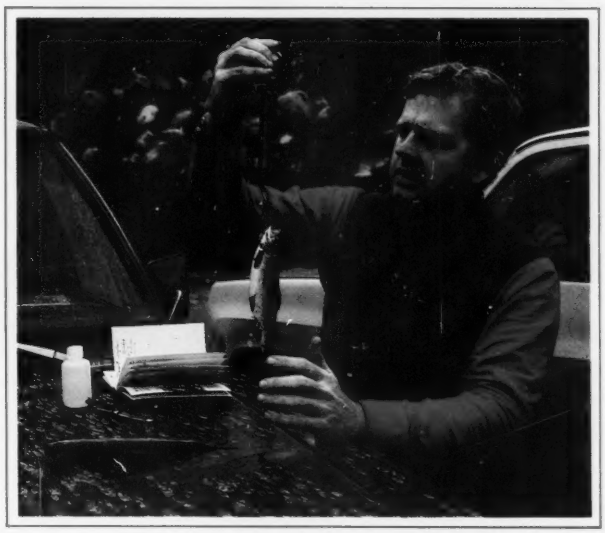
On-site investigations have found that lakes with the larger inlet streams receive the greatest amount of siltation when compared to those with small inlets or none at all. And, as might be expected, the study team has found that those waters remaining heavily clouded for long periods show an apparent low fish survival rate.

Concerns of Crawford and his crew about the threats and unknowns of the first winter's overall impact on these once beautiful high-country lakes have proved not so serious as expected. Early summer monitoring of four lakes checked for the first time and repeat visits to several others have been encouraging. Runoff from the surrounding hills was a negative factor but not as damaging as originally anticipated. Again, basic water chemistry tests turned out to be normal, and netted fish specimens were fat and in good shape from the lakes that were beginning to clear. Eastern brook trout from the murky waters of Panhandle Lake were thin. No fish were taken at St. Helens Lake, located just nine and a half kilometers north of the volcano and directly above Spirit Lake. St. Helens is still very turbid, no doubt because this lake sits in the bottom of a steep-sided bowl and catches all the runoff from those heavily ash-laden slopes. The water level here is also higher than usual from floating debris plugging the outlet.

Water temperatures are warming in all of the lakes and are increasing fish metabolic rates. This means that more



Tradedollar Lake, 18 kilometers northwest of the volcano, does not have a tree left around it. Rainstorms continually wash ash into the lake to cause extreme turbidity; however, trout have survived the catastrophe and seem to be in good condition.



Crawford examines trout, which appear to be healthy in spite of heavy ash siltation in the lake.

Elk on the upper North Fork of the Toutle River mud flow.

food is necessary to maintain their energy level. However, good weather brings a greater abundance of terrestrial insects as well as the normal build-up of aquatic species and so adds to a more available natural food supply. Biologist Crawford emphasizes that even though they do not have a complete analysis of food available in all of the lakes, he is optimistic about what he has seen. If progressively longer and longer "non-siltation periods" occur, the food chain in most lakes should be able to rebuild to a fish-sustaining level.

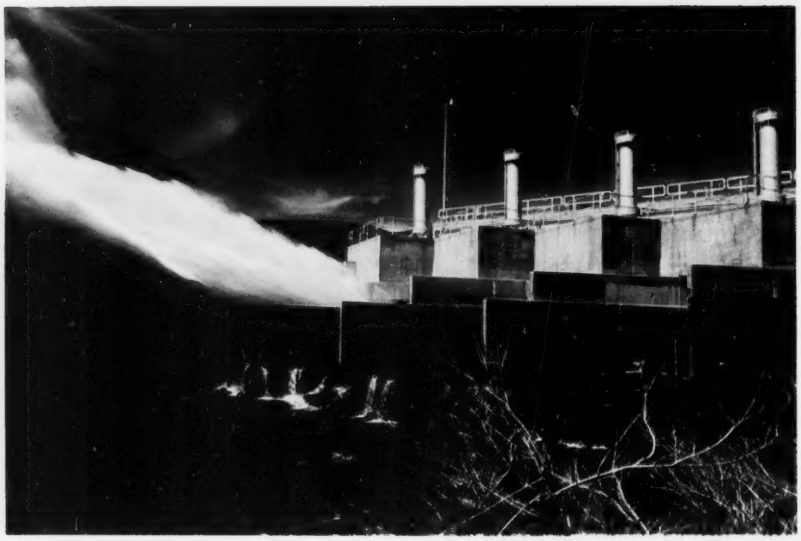
Unknown are the long-term effects of the logs, ash and other rock materials blown into the waters when the mountain exploded. When these things begin to break down chemically, it is conceivable that they could have an adverse effect on fish populations; by the same token, it is possible that there could be some benefits as well. Based on their investigations of what seems to be happening, biologists are voicing unofficial opinions that even some of the more severely altered lakes may support near-normal fish production within a few years. In any case, the evidence so far is encouraging.

The Game Department will not attempt to plant fish in any of the St. Helens blast-zone lakes until at least after 1983. It is important that numerous ecologic studies now under way in this zone be completed before any reintroduction of species begins. Two lakes directly north of the mountain, Grizzly and Ryan, will be established as long-term research lakes. No future fish planting is planned for these waters.

Time is now beginning to work in favor of the blast-zone lakes. With each passing day new plant growth is slowly rooting itself deeper, stabilizing the area's extensive covering of gray ash. The anticipation is that everything that was growing in the area before the eruption will eventually become reestablished over a period of years, although just how long that will take has not been predicted. To date, even though there has been only a year of growing time, the greening in some locations is apparent. Many root branches and stolons remained intact underground, where they have been slowly budding, and now are just beginning to show. Some of the first plants to begin emerging last summer in that desert-appearing landscape were ferns, fireweed, Canadian thistle, and a hardy grass-like rush. Not all ground cover within the area of devastation was lost. Some north slopes still had snow coverings that protected existing low level flora which is now serving as seed stock for neighboring defoliated areas.

Fish biologists are watching the succession of new growth with as much enthusiasm as are the botanists, for they know that less fish-damaging siltation will occur as more ground cover appears. Water quality in the Mount St. Helens lakes is always on Bruce Crawford's mind, for this is the key to maintaining a productive fishery. He would like nothing better than being able to report that these waters are again open for fishing—provided, that is, that the volcano cooperates . . . ■

Events, Deeds & Deliberations



WATERPOWER '81

by Morris William Clark, Jr.

On 22-24 June Waterpower '81, the second Federally sponsored international conference on hydropower, brought to Washington nearly a thousand people from the United States and 23 foreign countries.

The three-day conference was sponsored by the U.S. Army Corps of Engineers in cooperation with the Department of Energy, the Federal Energy Regulatory Commission, the Department of the Interior's Bureau of Reclamation, and the Department of Agriculture's Rural Electrification Administration and Farmers' Home Administration. As with Waterpower '79, this conference provided a forum for the exchange of hydropower information among interested professional and non-professional persons in the public, private and international sectors. In addition to the 150 paper presentations given at the five agency sessions, two international roundtables, and 35 technical paper sessions, there were eight major addresses and 48 exhibits.

Keynote speaker William R. Gianelli, Assistant Secretary of the Army for Civil Works, challenged the Waterpower '81 participants to be innovative and to search for new and

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more effective ways to stimulate and finance hydropower production. He emphasized that accomplishing such an objective would require a major Federal and private effort. Secretary Gianelli promised to help by having the Assistant Secretaries Committee, which he chairs, review the new "Principles and Standards for Planning and Evaluating Water Resource Projects," with the purpose of revising them to make them appropriately less onerous in the expeditious and orderly development of hydropower and other projects.

At the executive session, Lt. Gen. J. K. Bratton, Chief of Engineers, welcomed the participants and pointed out that U.S. Army sponsorship of a conference that deals with a non-military subject like hydropower is in keeping with its civil works mandate initiated in 1824 when the Corps of Engineers was given the responsibility for the development of an inland waterway system. He reviewed the National Hydropower Study currently being conducted by the Corps and described the 2100 potential hydropower sites identified in the study as consisting of about 1400 short-term development sites with a potential capacity of 19,000 megawatts and about 700 long-term development sites with a potential capacity of 38,000 megawatts—adding up to about 57,000 megawatts that could almost double present installed capacity. He explained that although the study is not intended to be a panacea for hydropower problems, the hope is that it will provide a planning grid that can be used to develop further a national course of action for both the private and Federal sectors. General Bratton noted that Waterpower '81 is also a healthy sign of international cooperation for moving toward solving common energy problems by better defining the role of hydropower.

Senator Frank Murkowski of Alaska, in his luncheon address on the last day of the conference, cautioned the participants to avoid repeating each other's mistakes by remembering that hydropower is readily available, is a cheap source of power, is renewable, and is environmentally clean. He said, "In the search for solutions for energy problems, I think we have overlooked an immediately available source, hydropower." He suggested that it is time we re-examine our goals and issues, in a modern context, and apply to the identified potential hydropower sites all of the technology we now have. Senator Murkowski warned the participants against deferring hydropower development and permitting themselves to be lulled by the present oil glut that is depressing prices.

At the closing session, Maj. Gen. Hugh G. Robinson, Southwestern Division engineer and chairman of the Waterpower '79 steering committee, provided an overview of the conference and insights on the progress made in hydropower development since Waterpower '79. He discussed the emphasis that Garrey Carruthers, Assistant Secretary of the Interior for Land and Water Resources, placed on new starts with hydro opportunities. General Robinson said, "From what I heard at this conference, I don't think you have to look very far; there are plenty of opportunities for hydropower new starts. We only must proceed as rapidly as we can." He cited Secretary Gianelli's call for shortened procedures and noted the efforts of the Federal Energy Regulatory Commission (FERC) to streamline its licensing and permitting process, efforts which have resulted in many permits being processed in 90 days or less. He noted that even with the streamlined process, FERC Commissioner Georgiana Sheldon in her speech had evaluated the U.S. as being in last place in hydropower development. He said that since Waterpower '79 we apparently have not done a very good job of explaining the necessities to the large number of local communities and cooperatives that are asking the "how to" questions. He cited the inappropriate definition of "short-term" as it is applicable to hydropower development—a period which could be as long as ten years. General Robinson said, "That's far too long to be termed short-term development when we know we can do better than that."

General Robinson posed the question, "What strides have we made towards the ultimate goal, power on line?" Then he answered, "I am sorry to tell you that we in the Corps of Engineers have not started another hydropower construction project." He suggested that, in addition to streamlining procedures, the Congress could produce legislation that would give to those agencies involved in hydropower development the authority to move hydropower projects of designated scales through to construction without having to stop and wait for action at each step. He declared that, without that type of legislation, fast track studies become a joke and discourage the persons who prepare the studies. He pointed out that planning studies are great, and that surely we need to keep the planning cycle going. He concluded, however, that while we recognize the need to first answer some very critical questions, "the bottom line question that we all must ask ourselves is, when is power going to be on line?"

A survey conducted at the closing session indicated that the participants want another Washington conference in 1983. Preliminary planning for Waterpower '83 has already begun. □

HOPPER DREDGES GOETHALS AND LANGFITT TO BE RETIRED

The U.S. Army Corps of Engineers will retire the medium class hopper dredge *Langfitt,* currently based at New Orleans, Louisiana, and the large class hopper dredge *Goethals,* currently based at Philadelphia, Pennsylvania, in 1982. The Chief of Engineers, Lieutenant General J. K. Bratton, said the action is being taken because two new Corps hopper dredges are scheduled for delivery in 1982; the exact retirement dates for the *Goethals* and *Langfitt* will be determined by the delivery dates of the new dredges. Another factor contributing to the Chief of Engineers' deci-

sion is that the commercial dredging industry has demonstrated an ability to take over more of the work which previously has been accomplished with Corps equipment. The *Goethals* was commissioned in 1938 and the *Langfitt* in 1947.

Through the Industry Capability Program, which was initiated by the U.S. Army Corps of Engineers in 1977, the dredging industry has been encouraged to construct new equipment and demonstrate an expanded capability which permits the Corps to reduce the number of dredges it operates. Public Law 95-269, passed in April 1978, provides that when the industry has the proven dredging capability, the Corps will advertise available work and award it to the lowest responsible bidder with the exception of that work set aside for the minimum fleet of Corps dredges. The law also authorized a "minimum fleet" for the Army Corps of Engineers which will be technologically modern and kept fully operational to provide for national defense and emergency needs. □

WATER RESOURCES DATA CENTER BECOMES OPERATIONAL

The Civil Works Directorate of the Corps of Engineers has designed and implemented a management briefing display center located on the 6th floor of Corps headquarters at 20 Massachusetts Avenue, Washington, D.C. The Water Resources Data Center (WRDC) houses a computer room, conference room and display room. The center, dedicated in early August and now fully operational, is a multipurpose facility designed to support the Office of the Chief of Engineers, the Director of Civil Works and ten field divisions of the Corps with centralized access to timely project and program performance information. It will assist in planning and control, serve as a "test bed" for evaluating data communications and display techniques, and provide central responses to inquiries from the White House, Congress, Federal agencies, state and local interests and the public.

The WRDC encompasses four systems: Data Base, Graphics Display, Emergency Operations Display and Communications.

The Data Base System has a Harris 5550 minicomputer whose principal function is to store and maintain a data base that supports rapid responses to queries. This system also provides for report generation, graphical manipulation and display of data, hard-copy production, application program development, work processing and remote computer communication. The data base itself presently consists of 11 Corps data systems.

The Graphics Display system consists of equipment that can create, display and provide hard-copy reproduction of graphics images. The primary use of the color graphics is to support conference room presentations. A device built into the conference room podium allows the speaker to control the images on the large display screen. The system can be operated from only one terminal, located in the computer room. This design feature prevents inadvertent disruption from remote terminals.

A planned Emergency Operations Display System is designed to provide similar graphics displays, as well as weather-related maps principally obtained from the National Weather Service Automated Field Operations and Services (AFOS) network. This system can transfer data to and from both the Data Base System and the Graphics Display System.

The Communications System supports data transfers to and from remote facilities, terminal operations within the building and weather data input from the AFOS network.

The WRDC, originally managed by the Water Resources Support Center, is now managed by the Office of Management and Staff Support. A facility management contractor operates the center. □

ENVIRONMENTAL TOXICOLOGISTS FACE PROBLEMS

The problems facing the young science of environmental toxicology are enormous, but the director of the National Institute of Environmental Health Sciences (NIEHS) is optimistic about support for the basic research and testing needed to deal with these problems.

Speaking at a recent conference sponsored by the Center for Environmental Toxicology at Michigan State University, Dr. David Rall pointed to the proliferation of chemicals in commerce and the discovery of countless inadequate toxic waste dumps as two major concerns of toxicologists.

"Today some 300 million pounds of chemicals are used in this country every year," he pointed out. "A fairly large fraction of that quantity is discarded as waste. Some 44,000 chemicals are in common use, with about 6000 new ones created and 500 entering commerce each year."

All this poses some extremely difficult scientific problems. Animal testing of chemicals is too expensive and time consuming to be used to assess the potential risk of even commonly used chemicals, let alone all the new ones.

The problem of toxic waste was dramatically illustrated by the furor over Love Canal, New York. But Rall says that situation is probably unique. The greater threat from inadequate toxic waste disposal is the contamination of groundwater.

"Love Canal is esentially a bathtub full of chemicals that overflowed," Rall explained. "But bathtub-type waste dumps are unusual. This one probably would have posed no problems except that the clay cap put over the waste was broken and the clay and some of the material under it was used for fill." Most toxic waste dumps in the United States are located over permeable ground. This means the potential for contamination of groundwater is very great.

"And as the thalidomide tradegy of the sixties demonstrated, the immediate efforts of exposure to chemicals aren't the only concern," Rall said. "A whole generation of people could be exposed to a substance before the long-term effects of such exposure begin to show up."

The tasks facing toxicology today fall into two broad programs: identifying potentially harmful substances and assessing the risk they pose to human health, and discovering the mechanisms of toxicity—how toxic substances do what they do.

Animal tests are often used to identify potentially harmful chemicals and evaluate the hazard to humans because there is a fairly close relationship between the response of animals to toxic materials and the response of humans. The problems with animal testing are that it costs too much and it takes too long—it can't hope to keep up with the number of chemicals being used and created.

To deal with the potential for widespread exposure to toxic substances, therefore, toxicologists will have to develop some rapid, short-term tests for identifying hazardous compounds and assessing the risk to humans. They are going to have to devise some ways to monitor exposure and to learn a great deal more about the mechanisms of toxic substances, both individually and in combination with other chemicals. □

LOWER GROUNDWATER LEVELS PROJECTED IN WESTERN KANSAS

The water table in a 12-square-mile area of northeastern Wichita County, Kansas, would decline an additional 15 to 30 feet by 1988 if pumping of groundwater in the surrounding 480-square-mile area were to continue at 1977 rates, according to a report published by the Department of the Interior's U.S. Geological Survey (USGS).

The report is part of a study done by the USGS in cooperation with the Western Kansas Groundwater Management District No. 1 to evaluate methods for conserving declining groundwater resources of the area. The 12-square-mile area in Wichita County was selected for intensive study as representative of areas in west central Kansas where water table declines are occurring in the Ogallala aquifer. Continued declines in this major aquifer (underground water-bearing rock unit) could affect agriculture over a six-state region of the Midwest.

The study describes one of the most heavily irrigated and severely groundwater depleted areas in the High Plains. In parts of the panhandle of Texas, a rapidly declining water table in the Ogallala and increased energy costs have caused farming by irrigation to become less profitable. In some areas, pumping rates have decreased and costs have increased to the point where it is no longer profitable to irrigate, and many farmers have returned to dry-land farming.

Groundwater levels have declined more than 62 feet in some parts of the western Kansas study area since 1950 and have declined an average of almost 48 feet from 1950 to 1978, mainly because of pumping for irrigation.

Pumping at one-half the 1977 rates in the overall 480-square-mile area would still cause the water table to decline in the smaller study area, but only by an additional five to 15 feet by 1988. If 1977 pumping rates were doubled, however, groundwater levels would be lowered an additional 25 to 40 feet in the study area by 1988.

"The gradual depletion of ground-water reserves has resulted in concern for the agricultural economy of west-central Kansas," the 59-page report says. "Because the economy largely depends on the continued production of food and fiber through irrigation, the continued availability of ground water is of immediate concern to state and local water-planning agencies.

"The Western Kansas Groundwater Mangement District No. 1 recognizes that conservation of ground water through efficient use is the most practical means for prolonging the availability of ground water for irrigation," the report adds. "Local irrigators are being encouraged to participate in a district-wide conservation program in which crop yields may be maintained or improved by efficient water use and timely irrigations."

Lloyd E. Dunlap, a USGS hydrologist in Garden City, Kansas, and principal author of the report, said water levels in the Ogallala aquifer in Kansas and other Plains states have been falling since irrigation became widespread after World War II. □

CHINESE WATER RESEARCHERS VISIT U.S.

In early June two engineers from China's Ministry of Water Conservancy began a four-week trip across the United States to study U.S. applications of remote sensing in crop forecasting and agricultural hydrology.

The Chinese team consisted of Chen Deji, chief engineer, Survey and Exploration Department, Yangtze Valley Planning Office in Wuhan; and Yang Jicheng, deputy chief of remote sensing, Application Center, Ministry of Water Conservancy, Beijing, China.

Quentin M. West, Director of the U.S. Department of Agriculture's Office of International Cooperation and Development, said the engineers were the first of 11 exchange teams the Chinese will send to the United States this year under the agreement of cooperation in science and technology signed by the two nations in 1979. The United States will send 12 scientific exchange teams to China in 1981. Eleven teams visited China in 1980 and three in 1979.

The scientific exchanges between the United States and the People's Republic of China will benefit both countries. According to West, the Chinese have had many centuries of

experience in dealing with soil conservation, land use and related agricultural activities.

The Chinese team spent its first week in discussions with USDA's Soil Conservation Service (SCS). West said the Chinese were interested in technical aspects of activities in which SCS is involved with regard to hydrology watersheds and riverbed technology and the AgRISTARS project. (AgRISTARS is the acronym for a joint research program for agriculture and resource inventory surveys through aerospace sensing. Cooperating agencies include USDA, National Aeronautics and Space Administration, Department of Commerce, Department of the Interior and the Agency for International Development.)

The Chinese met with Soil Conservation Service personnel in Harrisburg, Pennsylvania; Indianapolis, Indiana; Jackson, Mississippi; Temple, Texas; Phoenix, Arizona; and Davis/Berkeley, California. They also had an opportunity to study hydrology at Pennsylvania State University and the land application remote sensing (LARS) activities at Purdue University. □

WATER POLICY BOARD PROPOSED

A national water policy board to advise the President on water problems has been proposed in two congressional bills—one in the Senate and one in the House of Representatives. Although the the two measures differ, both would establish a National Board of Water Policy to replace the existing Water Resources Council, which President Reagan wants to eliminate. The Senate version proposes a five-member board composed of the secretaries of the Army, Interior, and Agriculture; the administrator of the Environmental Protection Agency; and an independent chairman. A five-member state advisory committee composed of persons from the National Governors Association would advise the board on national water problems. The House bill would establish a seven-member board with an advisory committee of 21 representatives from the states. (*Water News,* Virginia Water Resources Research Center, July 1981) □

"BUREAU OF RECLAMATION" REBORN

The Bureau of Reclamation, which underwent a poorly received name change to become the Water and Power Resources Service, has regained its historic title. Secretary of the Interior James Watt said, "The name of Bureau of Reclamation is one of historical significance as well as a symbol of excellence. Changing the name to Water and Power Resources Service was a mistake. The public we serve did not like it, nor did the employees who loyally worked for it. The name proved to be awkward, difficult to use in speech and writing and lacked a logical and convincing short form as a ready reference." □

Bookshelf

Freshwater Wetlands: A Guide to Common Indicator Plants of the Northeast, by Dennis W. Magee, treats 182 species that represent the majority of genera commonly encountered in freshwater wetlands throughout the northeast. The manual is organized into two major components, the first consisting of keys that are based on life form and arrangement of plant parts, the second consisting of a description of each species. Such factors as range, habitat, general characteristics, stem, leaves, inflorescence, fruit, and similar species are covered in the descriptions. The book is useful for those concerned with how a correct definition of wetland areas affects decisions about land use, development, and conservation. Clothbound copies are available for $20 each, paperbound for $8.95, from the University of Massachusetts Press, Amherst 01004.

Economics, Ethics, Ecology: Roots of Productive Conservation, edited by Walter E. Jeske, is a compilation of material presented at the 35th annual meeting of the Soil Conservation Society of America. This informative paperback is in 11 parts that provide discussions on topics such as economic realities, ethical perspectives, and sustained use of natural resources. A closer look is taken at three issues confronting North American nations—land planning, water management, and the implications of energy development for land and water. A look to the future of natural resources use and current resource issues in the context of economic realities, ethical values and ecological principles is presented in parts V through XI. This 454-page book is available from the Library of Congress for $10.00 The stock number is ISBN 0-935734-07-4.

Worldwatch Paper 44, **Rivers of Energy: The Hydropower Potential,** by Daniel Deudney, discusses the findings of a study conducted by Worldwatch Institute. In this study it was determined that falling water is the source of one-quarter of the world's electricity, and despite hydropower's prominence as an energy source, most of the energy potential in falling water remains untapped—if all economically available hydropower were harnessed, most of the world's electricity needs could be satisfied. The book gives the history and future of hydropower, small-scale hydro in developing countries, ways to make better use of existing dams and new directions for all countries to take. Copies of this paper are available for $2.00 each from the Library of Congress. The stock number is ISBN 0-916468-43-7.

Incentives in Water Quality Management: France and the Ruhr Area, by Blair T. Bower *et al.*, is a research paper prepared by Resources for the Future, Inc. This 302-page paperback consists of three parts: an overview of effluent charges and other implementation incentives in water quality management, water management in France, and water quality management in the Ruhr area of the Federal Republic of Germany. This research paper is available for $14.00 from the Johns Hopkins University Press, Baltimore, MD 21218. □

Coming Events

Waterfront Rehabilitation, University of Wisconsin-Extension, Madison, Wisconsin, 16–17 November 1981.

U.S. Army Corps of Engineers Remote Sensing Symposium, Radisson Plaza, Nashville, Tennessee, 30 November – 2 December 1981.

Eleventh Dredging Engineering Short Course, Texas A&M University, College Station, Texas, 11–15 January 1982. □

Changes of Command

Major General Bennett L. Lewis has been named executive deputy director of the Federal Emergency Management Agency in Washington, D.C. General Lewis was North Atlantic Division engineer.

Brigadier General George R. Robertson has been assigned as commander of the Corps' MX Program Agency at Norton Air Force Base, San Bernadino, California. He formerly served as deputy director of Civil Works, Office of the Chief of Engineers, in Washington, D.C.

Brigadier General Thomas A. Sands became North Atlantic Division engineer, New York City, in August. He had been New Orleans district engineer.

Brigadier General James W. Van Loben Sels has succeeded **Major General Richard M. Wells** as North Pacific Division engineer, Portland, Oregon. General Van Loben Sels previously commanded the 18th Engineer Brigade in Karlsruhe, Germany.

Colonel Tilford C. Creel in July became commander and director of the Waterways Experiment Station, Vicksburg, Mississippi. He succeeds **Colonel Nelson P. Conover,** who retired in November 1980. Colonel Creel previously served as district engineer of the Savannah District, Savannah, Georgia.

Colonel Robert C. Lee has become New Orleans district engineer, New Orleans, Louisiana. Colonel Lee was chief of the Management Division, Office of the Deputy Chief of Staff, Engineer, U.S. Army, Europe. □

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Looking southeast over Elk and Hanaford lakes toward Mount St. Helens quietly puffing steam some fifteen kilometers distant. *See "Surviving the Blast" on page 38.* (Photo by Austin Post, U.S. Geological Survey.)